Automated Selection of Topographic Base Information for Thematic Maps

By

Rosene Kannich

Supervisors
Dr David Forrest
Dr Jane Elizabeth Drummond

A Thesis Submitted for the Degree of
Master of Science

Department of Geographical and Earth Sciences,
Facuty of Physical Sciences,
University of Glasgow

2007

Abstract

Modern GIS are capable of producing well designed maps but offer little assistance to users with little cartographic knowledge. Maps which are produced by such users may have a lot of cartographic errors and be of poor design. Thus, it is very necessary to build cartographic knowledge into GIS to help users to make effective use of such programs and produce basic maps conforming to basic principles of design. One possible way of improving map design in GIS is to build cartographic knowledge into the system.

On particular area where such cartographic knowledge could be applied is in the selection of base (topographic) information for special topic maps. The selection will depend upon map topic, map purpose, map scale, and the amount of detail required for the particular map. A topographic database at 1:250 000 has been used to starting point for this study and the scale of output maps limited to the 1:250 000 to 1:1000 000 range. To build a knowledge base of map content, published maps have been examined, and two aspects have been considered: maps with the same topic at different scales; and maps at the same scale but with different topics. For further development to the knowledge base, a questionnaire has been sent to cartographers and expert map users to determine what they consider should be the map content for maps on a range of topics at several scales. An initial examination of the knowledge base produced from the survey of published mapping highlights some anomalies, but by using the knowledge of the cartographers and map users, the knowledge base is revised.

To apply this knowledge, a formula for selecting appropriate base information is tested and the results show that the approach does produce satisfactory results. It is suggested this is implemented within a GIS to allow users to focus on the analysis data, with maps produced having appropriate base information depending on the topic, scale and the required level of detail automatically.

Declaration

I, Rosene Kannich, declare that this thesis is the product of my own work, except where indicated, and has not been submitted by myself or any other person for any degree at this or any other university.

Rosene Kannich
25/04/2008

Acknowledgements

It is with sincere appreciation and indebtedness that I acknowledge the following people who give their guidance, support and encouragement .

Dr David Forrest for serving as my academic advisor. I would like to thank him for his expertise in the field of cartography as well as his patience as an English grammar checker during the revisions.

Dr Jane Elizabeth Drummond for her counsel and special friendship which will always be appreciated.

Mrs Ann Dunlop and Mr Brain Black for their help.

All my family members and my friends for their constant encouragement. The sincere gratitude is particularly expressed to my husband and my son for their understanding, support, and help towards the accomplishment of my degree.

Special thanks to Al-Baath university for supporting me during this research.

Contents

List of figures

List of Tables

Table.....Page

Chapter 1
Introduction

Maps are very important elements in our lives. We use them in many different circumstances. They may be used in the field or laboratory, under sunlight, or in the office. But making maps is a complicated task. There are many elements we have to deal with while we are producing them. All these elements are important and require knowledge, understanding and often considerable skill if a satisfactory map is to result.

Cartography is concerned with the design and production of maps. It includes artistic, scientific, and technical aspects. Cartography is also about the gathering, storage, evaluation and visualization of geographic information including the selection and generalization of the data to be suitable for the map scale, map purpose, and map user.

Geographic Information Systems (GIS) are computer based spatial data systems. They are used to capture, edit, store, manipulate and analyse spatial data. GIS have three major components: the first is a database, the second is a spatial analysis and modelling capability, and the third is a graphic display system. There is a strong link between GIS and cartography. The data that GIS use are often sourced from existing maps by scanning or digitizing these maps. Converting cartographic information into a geographical database is an essential part of developing a GIS. Maps are also one of the major forms of output from GIS, which even in their most basic form require some cartographic design input.

Cartographers work in designing, producing and using maps. They work to develop new ways of representing geographic information, creating and storing complex data, developing new projections and measuring the map's errors. Map making is a part of both science and art, even when maps are produced by computers. The mapmaker has a great influence on the final map, because they are in control of the design. However, not all mapmakers are trained in

cartography and this lack of cartographic design knowledge may have a detrimental impact on map design.

Every design has a different environment. That is why each map design will have a number of possible solutions. These solutions are not equal in achieving the mapping goal. Learning how to evaluate a map's design is a very important aspect of becoming a better cartographer. Thus the map designer must be able to evaluate the design alternatives and think very careful about possible solutions to creating a good design. A well-designed map is, ideally, simple and uncomplicated; it should be aesthetically pleasing and not look contrived. In addition, good map design results from a clear understanding of purpose, a well developed imagination able to visualize the outcome, and skill in working with available technology. In designing a map it could be argued that the first stage is the evaluation of user requirements. Subsequently, the relationship between map scale and available data needs to be considered. For example, when we choose a large map scale, we should have more detailed information in the map, and when we have a small map scale, there will generally be less information available in the map. In addition to purpose and scale, different map topics will require different contents.

No map should be designed without reference to the purpose for which it will be used. The mapmaker should know the purpose of the map, and then it can designed for this intended use. The mapmaker also decides how much information should be included in the map. In designing any map, classification and selection of information are very important steps. Selection of data starts by choosing certain general classes (types) of information. As the data is compiled and decisions about content made, this selection will be refined until a final detailed list on contents can be defined. A distinction is made between *topographic maps*, which show the most visible features of the landscape together with places names, and *thematic maps,* which are designed to emphasize specific features. Thematic maps require some topographic (base) information to provide background and locational context for the special subject information. The nature of this topographic base information will depend on the map topics.

The first job the mapmaker has to do is to select the information that should be mapped. For that, the mapmaker should ask three questions: " where? what? and why?" The purpose of the map will answer the question *why* and will greatly influence *what* should be included in order to answer this question. In a practical situation, answering these two questions may also depend on the information available.

Map purpose is an essential element in producing a map, but it is a not the only guide to selecting the map information. When the map's purpose is known, the phenomena that will support the purpose can be chosen, but if the mapmaker includes everything that might be relevant to the map's purpose, the map may become cluttered and unusable. The skill is in choosing sufficient information to serve the purpose, but also knowing what can be eliminated to make the map useable.

After selection the general classes of information that will be mapped, the mapmaker should take the most important decision in their work. This decision is at what scale they will make their map. The scale is a relationship between the map and the reality. It depends more on map purpose than anything else. Mapmakers cannot copy the environment at its natural size. They must find a map scale that will be suitable for the detail required and area covered.

Since the 1970's there have been great changes in the way maps are produced. Today most maps are produced using digital data and computer based mapping systems. If this data is recorded as digital data and entered into a digital database then it can be used repeatedly and for a wide range of purposes. The reduction in the cost of digital technology and increased availability of digital data means that many people now have access to cartographic and GIS capabilities. This technology will allow many map users, who have a little knowledge or understanding of the basic principles of map design, to produce their own maps. There is much evidence that many of these maps are poorly designed. There may no problem with this poor design when maps are intended for personal use and the user has a good understanding of the data. A problem

arises when the mapmaker has poor background knowledge in map design, but produces maps to be used by others. This can easily lead to misinterpretation of the information and poor decision making as a result of poor map design

The best way to reduce poor map design would be to increase the cartographic education of the map makers and GIS users, but basic education in mapping tends to focus on map use and improvement of skill in extracting information from maps. Rarely is any attention paid to map design. Most GIS courses focus on learning to use the technology, data entry and analysis and again often pay little attention to map design. One solution to this lack of cartographic design education is to improve the ability of GIS to produce sensible maps. This will involve incorporating cartographic expertise within the system and is a primary goal of this research**.**

Over the last 30 years there has been considerable development of computer programs which include the knowledge of how an expert can solve a problem. Such a program is called an “Expert System” although some prefer the term “rule-based system” or “knowledge based systems (KBS)” for more basic problem solving systems and reserve “expert system” or “intelligent knowledge based system (IKBS)” for much more advanced, possibly future, developments.

An Expert System (ES) is a computer program that includes a register of information that an expert uses to solve a problem in order to help a non-expert to solve a problem or make a decision. Typically this ‘knowledge base’ includes facts and rules about the problem. We cannot call all computer programs that solve a problem an expert system. That is because an ES accepts and uses uncertain and incomplete evidence. In addition, an expert system explains why questions are asked and described how conclusions are reached. In ES, the interaction is flexible and should emphasize the requirements of the user.

Essentially then, an expert system interacts with a user to solve a problem. It does this by accessing a store of knowledge provided by an expert in solving the particular problem. Clearly this has application to the design of maps and many cartographic design expert systems have been developed or

proposed in recent years. In theory by using an expert system a user with little or no background in a problem area can solve specific problems.

Although expert systems can be applied to a wide range of mapping tasks, or to the development of a comprehensive map design expert system interfaced to a commercial GIS, there are many sub tasks that can be identified and progress towards a comprehensive system requires that each of these problems be solved. The literature on expert systems suggest that focusing on a narrow domain (i.e. a limited problem area) is more likely to be successful in the first instance, thus this project focuses on applying a knowledge based system approach to a very small part of the map design and production process.

- **Project Aims**

The aim of this project is to find the topographic feature classes to include in various types of maps within a certain scale range. Thus this study will help in automating decisions about the data that should be included in a map and relieve the map author of this task. The automated solution will lead to improved selection of data in comparison to simply using standard defaults, by applying knowledge stored in a knowledge base.

A further aim of this study is to find the relationship between map topic, map purpose, map scale, and the classes of topographic base information that should be included. To achieve this two different sources of knowledge are used.

First, maps at different scales and a variety of topics have been examined. Collecting data from these maps will focus on two outcomes. In the first, maps with different scales and same topic will be compared to find how changing scale affects the data. In the second aspect, comparing different map topics but at the same scales will show the relationship between map topic and map features that should be included. Analysis of data collected on these two ways will form the basis of rules for selecting information for maps on various topics over a range of scales. All the data has been collected from maps at or around scales of 1:250000, 1:500000, and 1:1000000. These maps are of

different map topics, such as topographic, political, population, land use, relief, land cover, climate, communication, and environment science and so will give information on what should be included in maps on a range of topics.

The second source of data is a questionnaire. This questionnaire will be sent to cartographic and subject experts, and will cover the same topics and scales as the maps studied.

To use the knowledge base of map content to select the features which will be included in the maps of various topics at different scales, two different approaches have been examined. These have previously been used for selection of content on very small-scale maps. The current project applies them to maps in a larger scale range. After assessing these two methods and comparing the results, a final knowledge base and automated selection criteria are created and used to produce example maps at a range of scales for several map topics.

- **Thesis Structure**

Chapter 2 discusses the relation between map contents and the various decisions that must be taken in the early stages of producing a map. It also explains the relationship between these contents and how various elements will affect designing and producing the map.

Chapter 3 introduces the concept and development of knowledge base systems. It discusses using expert systems and artificial intelligence in building the knowledge base which will help in automated map production.

Chapter 4 presents the data collection methods and uses this data to building a knowledge base to determine the relevance of the range of topographic information in a database to maps in various topics. Knowledge bases from the two methods of data collection are compared and are used together with information from previous studies to create a final knowledge base for map data selection.

Having created the knowledge base, Chapter 5 examines how this can be applied to the selection process. Two different methods previously applied to smaller scale datasets are compared. A series of maps on different topics at 3 different scales are produced using the automated selection process and the changes in content discussed.

Finally, Chapter 6 discusses what has been done during this research, and how well the aims of the research have been achieved. It also looks at issues that remain to be resolved and directions for future research.

Chapter2
Map Composition

2.1 Introduction

Designing maps is a very complex task. It includes several different stages, each one having its own processes. According to Dent (1999, p.237) “the map design process, like any act of designing, includes six essential stages: problem identification, preliminary ideas, design refinement, analysis, decision, and implementation.”

These stages include the similitude between map purpose, map-use, and other factors. Also, the primary ideas will be decided, and solving problems will be based on creative thinking. All primary ideas that have been chosen will be evaluated, accepted or rejected. In addition, as the ideas are refined and sharpened decisions are made which will affect the whole process. Part of the development of these ideas is to create ‘models’ to help in the visualization process. Today, map designers prefer to use computer models in their work. Designers may need to develop detailed drawings to test their decisions and rejected or accepted their ideas. Prototypes may be created at the decision stage. Implementation is the final stage, where the actual production of the final map is carried out.

Sometimes the cartographer will go through some of these stages many times until a solution to the design problem is found. Every design has a different environment. It is also the case that any situation may have many possible solutions. These solutions are not equal in achieving the mapping goal. As a consequence, learning how to evaluate a map’s design is a very important aspect of becoming a better cartographer. Thus the map designer must be able to evaluate the design alternatives, and think very careful about developing a good design. Good design is clear and uncomplicated design. As well, it is elegant and does not look contrived. In addition, good map design is a result of

clear purpose, well-developed imagination and visualization, and good skill in working with available technology.

2.2 Map composition

Composition is an arrangement stage in designing maps. At this stage, the major elements will be chosen and arranged. Keates (1996) states that composition is very important, but is a topic very much neglected in writing on cartography. Scale, area, and content of the map will be determined during this stage, while Robinson et al (1995, p.332) said: “Map composition can rarely stand alone. Explanatory aids such as titles, legends, insets, scales and direction indicators are also standard components of map composition.” Thus composition involves decisions about four elements: the geographical area, the general content of the map, the scale and the format. Once these have been determined the overall layout of the map can be developed. It is therefore an organizing stage; once these fundamental decisions have been made, progress can be made to the detailed design and production stages.

For a well designed map to result it is important to devote appropriate effort to map composition. For example, the map scale should be suitable for the available information and the map should not have too much detail for the chosen scale. The cartographer should be aware of the connection between map content and its representation, which will depend on an understanding of the data and a visual imagination of the final outcome. One element of composition is the choice of the content of the map. This may not be a detailed consideration of all the individual features that will be included, but more holistic decisions about the general content. For example, should the map include roads or not?

While the general content may be decided as part of composition, we cannot totally separate the decisions about the selection of the data and its representation. This is because the map’s design is affected by the image of the map as a body of information. Although selection of data must take place at an early stage, problems may appear during compilation or at the cartographic representation stage resulting in data selection being reconsidered.

Thus, during map composition there are several initial important decisions that have to be made. These decisions are the geographical area that will be mapped, the format (size) of the output, and the scale of the output. Moreover, the level of detail of the available or required data affects the choice of the scale (Forrest, 1997). Each of these aspects and relationships between them are considered below.

2.2.1 Map location

According to Keates (1996) the first decision will be about the geographical area, because no map can be made without a decision about it. The area to be mapped may have an effect on availability of data. Also the scale and the format will be affected by the size of this area. It is not possible to map a large area at a large scale within a small format.

As a general rule the map author will know the extent of the area to be mapped, although they may be vague about the exact limits. The purpose of the map will affect the area that should to be included. Depending on the scale and the features to be mapped it may be necessary to extend the area covered to provide location context.

Location may be specified by latitude and longitude limits, by projection co-ordinates, or by the places that must be included. Interactive systems may also allow graphical methods. Ultimately, accurate area limits are very important. We need to know the exact extend of the area which will plotted, in order to ensure it will fit in the available space at the desired scale.

2.2.2 Format

Format (size and shape) may be a standard or a customized size sheet of paper, a whole page in a book or atlas, a part of page, a wall map, or a computer screen. In a few cases the overall map size is not a major issue as when the map is produced it can be divided it into several sheets, but this will still require a decision about sheet format. Whatever the format will be, the map must fit within it (Forrest, 1997). Interactive maps may offer the apparent advantage of being

able to scroll across a larger area than can be seen on the screen at one time, but this may pose problems for the user recognizing patterns over the whole area, estimating distances, or estimating the number of instances of objects.

2.2.3 Scale

Making maps is impossible without determining scale. All map composition elements are important, but map scale is the most critical. Scale affects the information level that may be depicted and often influences representation methods. But understanding scale depends on the map author's experiences. According to Robinson et al (1995) determining the relation between the map and the area that is being mapped depends on the map scale. Scale is also prescribed by mapping media format; as the map scale becomes smaller then the area that can be mapped within a fixed format will become larger. Many map users have a poor understanding of scale; they may not know the most suitable scale for their purpose. Also if they want to print a map they do not know what is the best scale, and if the chosen scale will be suitable for the paper size. More significantly, often they do not understand exactly what scale means in terms of what can be represented and how or how changing map scale will affect their work.

2.2.3.1 Scale definitions

In dictionaries, scale has many meanings. Collins dictionary includes three primary entries. The third entry includes nine uses as a noun, and four as a verb. Of the uses of scale as a noun what we are concerned with is the third definition.

Scale[3] n. 3a. The ratio between the size of something real and that of a representation of it. 3b (as modifier): a scale model.

(Collins, 2000)

In the Oxford dictionary, scale also has three primary entries, and of these the relevant entry is the third one. This entry includes five uses as a noun and three as a verb. In the uses of scale as a verb, we are concerned with the second meaning.

Scale[3] v. 2 tr represent in proportional dimensions; reduce to a common scale. (Fowler, 1995)

Despite scale being a well-known and defined term, many map users still have a confused understanding of scale, how scale is be used in the correct way, and how to calculate a map scale.

2.2.3.2 Types of scales

Map scale is a ratio between map distance and earth distance. It may be separated to two groups: linear scale and areal scale.

- Linear scale

The relation between map distance to the earth distance may be shown in terms of linear measurement in three ways: word statements, a fraction, or a graphic scale.

A word statement is the most common way to describe scale in everyday language. It uses phrases scale as “centimetres to a kilometres” or “inches to the mile”, but sometimes these phrases will be “one kilometre to the centimetre”. This latter style may cause a problem with understanding. However, the shorter measure refers to the map while the larger measure refers to the earth.

One problem with the word statement may be the mixing of distance units. For instance, “one centimetre to one kilometre” requires the user to appreciate the ratio between different units. While a more correct phrase would be like: “one centimetre to 200,000 centimetres”, which gives a direct ratio of measurement. That is why we have to be careful and put this problem in our mind when we deal with maps.

Representative fraction (RF) is a ratio between map and ground distance. In addition, it is the easiest way to describe scale. It can be written as 1/250 000 or 1:250 000. The numerator is a map distance. Map and ground distance must be given in the same unit of measurement.

The third way to describe the relation between map and ground distance is by using a graphic scale, sometimes it called a bar scale. Normally this is read

from left to right starting at zero. Sometimes this scale does not start at zero, but it is extended to left of zero using smaller markings. This case will help us to determine measurements of whole units and fractions of units.

The scale bar has many useful characteristics. First, when a map is enlarged or reduced, the scale bar changes size in direct proportion to the map, whereas the word statement and RF will lose their meaning. Second, the bar scale can be constructed to allow the comparison of several units of measurement, such as imperial units and kilometres. Finally, the scale bar is easy to use when estimating distances on a map.

Sometimes mapmakers replace the standard bar scale with a variable graphic scale. That is happened when maps show the whole Earth; in this case the scale may vary significantly from one part to another on the map.

- Areal scale:

The most common way to describe scale is a linear scale, but sometimes the map user is interested in the area of things. This scale could be expressed in the form ”one square inch to four square miles”. It is equal “1/126720” in linear scale. If the map scale is given as a linear scale, we can convert it to an areal scale, but it may not be simple (Muehrcke and Muehrcke, 1992). Area scale may also be shown graphically by a square or rectangle of an appropriate size.

2.2.3.3 determining scales

All maps are constructed to a scale. Difficulties appear when we need to select certain detail from source material, and reproduction it in a different scale, in addition to changing projection at the same time.

The shapes of areas of the Earth will be affected by the projection on which the map is constructed. This problem is particularly critical for larger areas, probably represented at very small scales. When there is a wide choice of projection, then the variations in the shape of the mapped area can be matched and the format which provides the best fit and maximum scale can be selected.

In most cases, except at very small scales, the data is likely to be stored in a projection system and most GIS users are unlikely to change this.

2.2.4 The relation between the map scale and the level of detail:

In map design selecting data is a key stage. This data should serve the map's purpose and should be suitable for the map scale. Keates (1996) notes that determining the area and the scale will have an affect on the data. Normally, there is a relationship between map scale and available data. When map scale is small fewer details can be shown, thus scale is the most important limiting factor in the amount data that can be property represented. For example, when a large scale has been chosen then the map should have more detailed information, while at a small scale less detail will be included. This does not mean that point and line symbols should necessarily be smaller in size as map scale decreases. As scale decreases they will take up a greater proportion of the map area (i.e. exaggeration increases) and hence there comes a point where data must be reduced.

On the other hand, the quantity and quality of the data should be adequate to support the map purpose. Each map design will require different data. However, if the available data is insufficient and of poor quality no tricks of map design will create a good map.

	Large scale	**Small scale**
Area mapped	Small	Large
Information detail	More	Less
Representation	Less generalized	More generalized

2.2.5 The relationship between location, map scale and the format

Clearly, there is an interdependency between area to be mapped, format and scale. The problem is how we can work with all these elements in the correct way to give the best result. The suggested scale in the first stage may be quite unsatisfactory for the amount of information necessary. The result is that one of them or both must be changed. However the geographical area that has to be

mapped at a suitable scale for the level of information required must fit within the chosen format (Keates, 1996).

The relationship between scale and format is critical; if one of them changes it will affect the other. If the map limits are fixed, the area covered by it at the chosen map scale cannot exceed the selected format, but the map area should not be too small in relation to the selected format. While less critical, if the mapped area dimensions are less than 60% of the chosen format dimension then the map author should probably choose a larger scale, or a more appropriate format.

2.2.6 map purpose and the available data

The map's final character should also reflect the map's purpose. Maps can serve many roles, but rarely can one design serve all needs very well. Also, if mapmakers try to serve too many masters, the result will be that they cannot serve anyone as well as they want. Furthermore, the breadth of purpose considered during map design will have an effect on its use (Muehrcke and Muehrcke, 1992).

The purpose of the map is the essential determinant of the map's final form. Thus, the map designer should fit all their design decisions as much as possible to the map's purpose. According to Robinson et al (1995) mapping purpose separates into two aspects: substantive objective, and affective objective. The first aspect relates to the information which should be included in the map produced. The main importance in this aspect is the breadth of purpose. General maps are designed to serve multiple purposes, while special topic maps focus on overall form. When the number of objectives of the map increase, then it becomes hard to incorporate them all successfully. The second aspect concerned is the map's total look, and how the information will be portrayed on the map. The map should not be too dark or light, too open or crowded. Design decisions will determine if the map appears precise or approximate, or modern or traditional.

The data which will be used in designing the map should be adequate to support the map purpose. Furthermore, according to Robinson et al (1995), the quality of this data should be compatible with the map purpose. For example, poor quality data will be mapped at small scale and less detail.

2.2.7 General elements of composition

Titles, legends, scale bars, direction indicators and explanatory text are essential elements of map composition. These items will serve the map purpose by identifying the place, subject matter, meaning of symbols, orientation and so on. These items appear as a minor notation on large-scale maps. For example, the legend may be a common item for all maps in a series, and it may not appear on individual maps being printed separately. Furthermore, in an atlas the legend may be provided at the beginning as a reference. On smaller scale individual maps, these items will take a place within the map frame (Robinson, 1984). These items are often collectively referred to as “marginalia” or “map furniture”.

According to Robinson et al (1995, p: 335): “a title serves a variety of functions. Sometimes it reveals the map’s subject or the area covered by the map. In such a case, it is as important as a label on a medicine bottle.” It helps the reader to be clear about the map subject, or about the area that appears in the map. In addition, the title may be useful to the designer as a shape. It may be used to help balance the composition. Sometimes maps are obvious in their subjects; in this case we do not need a title on the map.

Legends are the keys to most maps. They are a general guide to the various symbols that are used on the map. Furthermore, a symbol should not be used on the map if it is not explain in the legend. A symbol should appear in the legend exactly as it appears on the map; the same size, shape and colour (Dent, 1999). Where there are many different classes of information the map legend may require a significant amount of space that must be reserved during the composition stage.

Maps will be used in different circumstances. They may be used in the field or laboratory, under sunlight or in the office. Map designers keep these

conditions in their mind, but they have a little control over how the map will be used (Muehrcke and Muehrcke, 1992). The maps being considered in this project are most likely to be used in an office environment, either as flat printed maps or viewed on a computer screen, so there are no special circumstances to consider.

Also, maps are made for variety of audiences. Each individual has a different education, geographical knowledge and perceptual limitations. Novice map users prefer the more intuitive pictographic symbols, while elderly people have difficulty seeing small symbols and type, especially when the map is crowded. Also, ideally the map should be unsophisticated and clear for the reader (Robinson et al, 1995). Thinking about the audience or map user guides the cartographer during the design process. It is very useful for the cartographer to know the age, education level and the map user skill. But often the cartographer does not have much knowledge about who will use the map

2.3 Conclusion

In conclusion, map content is strongly affected by the map topic, the level of detail required and the map scale. Also, map design will be successful if the map is suited to the needs of the users, clear and easy to use, accurate and without errors or distortions. The most important initial element is map composition. If the designer takes care with this, then the potential for good design is increased and the user will have a map with appropriate content and suitable for their needs. During this study key elements of composition will be focused on and with a view to automating this stage. The following flow chart (Figure 2.1) will help in understanding this relation between all these components.

How systems could be developed to assist map makers with map composition, along with an introduction to the concept and development of knowledge based systems, is the focus of chapter 3.

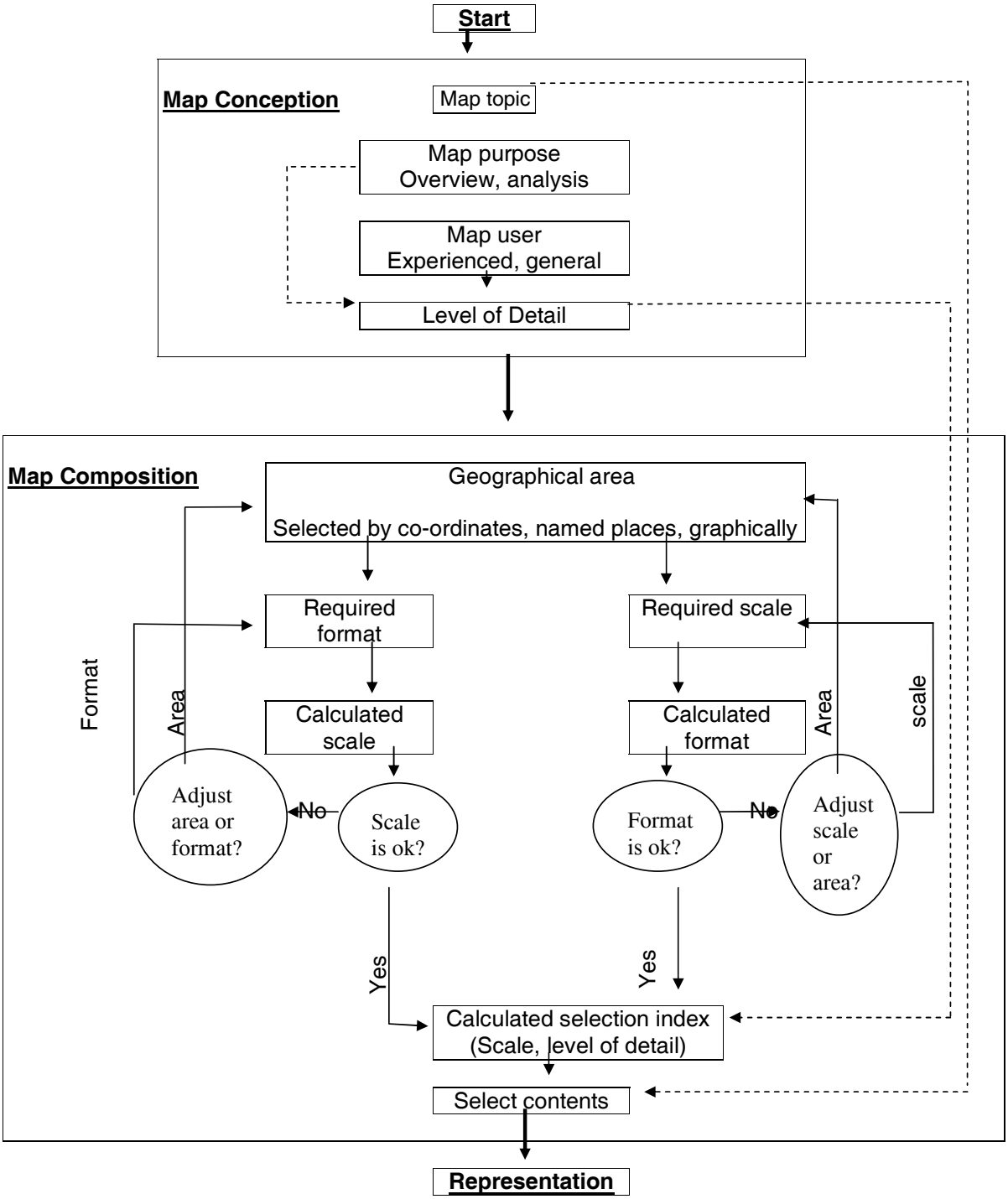


Figure 2.1. The process of selecting map contents.

Chapter 3
Methodology

3.1 Introduction

Determining which feature classes should be included in the map will depend on the map topic, the level of detail required, and the map scale. Choosing these features needs an experienced designer or the map may be poorly designed. Thus to help a map maker who has no experience, automating the selection stage is one way of solving this problem. This automation could be done with the help of an expert system.

An Expert System (ES), sometimes called a Knowledge Based System (KBS), is a program that includes structured knowledge which an expert uses to solve a problem. Copeland (1993, p.30) said: “an expert system is a program dedicated to solving problems and giving advice within a specialized area of knowledge-such as medical diagnosis, automobile design, or geological prospecting.” AI scientists worked hard to simulate the complicated process of thinking and they tried to find general methods that can be used to solve broad classes of problems and used for general-purpose programs.

Expert Systems should be applied to topics in which there are human practitioners who can solve a problem better than most other people. Typically they have been developed to help users with a basic knowledge of the topic of the system rather than for general users with no background in the subject.

The main elements in the development of an expert system are the expert system itself, the domain (subject) expert, the knowledge engineer, the expert system building tool, and the user. ”The expert system is the collection of programs or computer software that solves problems in the domain of interest” (Waterman, 1986, p.8). Furthermore, it is called a system because it contains a problem solving component and a support component. The support component will help the user interact with the main programs. Also, it will help the expert

system builder in testing and evaluating the program. Figure (3.1) shows the expert system components.

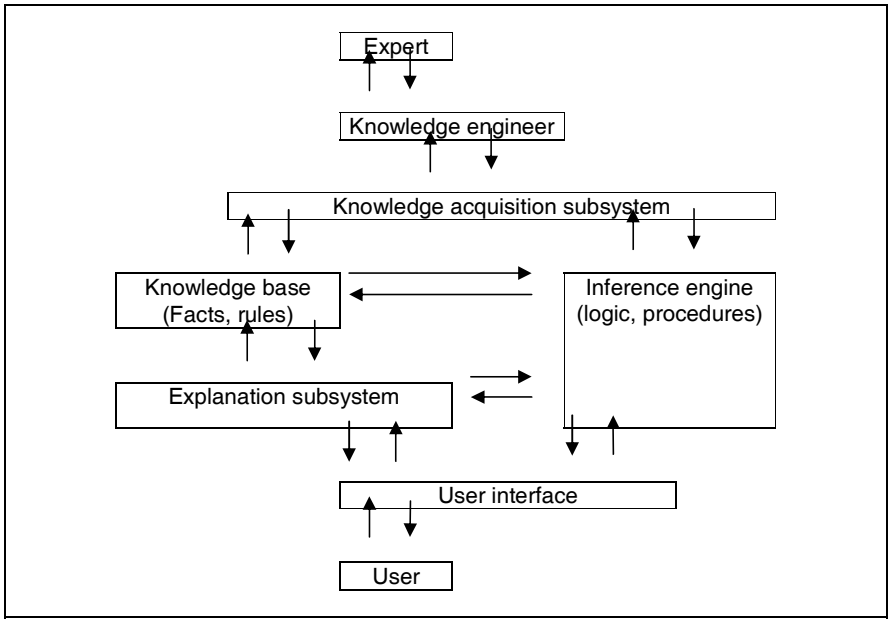


Figure (3.1) Expert system components

Generally, ES have been construction for well-structured problems, which can be easily formalized. An expert system stores facts and rules about a problem and applies inference operations to these to search for a solution to the problem. An ES may produce a single solution, or search for multiple solutions and arrange them in order of probability. One difference between an ES and a conventional algorithmic program is the disconnection of the specific knowledge about the problem from the set of the general inference mechanisms that work on the knowledge.

One of the most important requirements to make expert system development possible is that there are people generally acknowledged as having an extremely high level of expertise in the problem area. Those people with such knowledge are better than a beginner at solving problems in the domain. Without this knowledge and development effort it will not be possible to produce a truly

skilful program. Also, the experts should be able to explain the methods which they use in solving domain problems. If experts cannot do this, the knowledge engineers will have little success in loading the knowledge into a system.

Cartographic design is a potential area for the application of Expert Systems. A major concern is the increasing the number of maps which are being produced by people who have some knowledge of the information which they need to display using a map and who have access to a computer mapping program or GIS, but who have no cartographic background. Potentially an Expert System or Knowledge Based System could assist them to produce maps which conform to the basic principles and rules of good map design.

Within cartographic design, two limiting elements must be discussed: map topic and scale. If the topic is limited to a single subject, or small group of related subjects, then rules for these maps at a wide range of scale could be developed. If a broader range of topics is needed, then in order to progress to a practicable system, the range of map scales considered must be limited. It is unlikely that the expert system will be able to design maps of all kinds at all scales, or that the maps that produced by this system will be good as the maps produced by an expert cartographer. However, maps produced should conform to basic principles of good cartographic design. The map design process must be formalized before developing a working system. This formalization will rely on an understanding of the information and the processes involved in producing a map. The cartographic expert system should follow the steps which a cartographic expert follows. The main aim of the system is to help users; at no point should they be left wondering what to do next, and the users should not be left to search through menus to begin the next stage.

The process of building an ES is called “knowledge engineering”. Typically, this knowledge involves a form of interaction between the expert system builder and one or more human experts. The result will always be a computer program which solves problems in the same manner as human experts.

3.2 The problem

In the digital age, the topographic information will be stored in a database. Producing the base map simply requires selecting the appropriate feature codes or layers from stored topographic information. The map author needs to decide which features should be included in the map. Succinctly put, the problem to be addressed by this project is how to select appropriate topographic base information for maps of a wide variety of topics at a range of different scales.

There is a very important decision that must be made before selecting the appropriate classes of base information. This decision is about the overall amount of information to include in the map. This decision depends on many factors like the map topic, the level of required detail, the level of detail in the topographic database and how it is structured, the base data scale, and the final map scale.

In fact, two scales need to be considered. The first scale is the actual scale of the output map; the second is the notional scale of database information. Technically, digital data has no scale; it can be plotted at any scale. If it is plotted at scale larger than the source of the data, then the map will look crude and any errors will be enlarged. On the other hand, if the scale is significantly smaller than the source map scale, then problems with legibility will appear and generalization will be required solve these problems. Thus it is important to know the source scale of the data in the database.

The system to be developed will have a basic “knowledge” of a number of map topics. This system could have a menu of possible map topics, but this will be very complex because there are a large number of possible topics and a various names for one topic. The author must be able to select the topic from those available, or desirable in such a way that the system can match it to those in its database. It is likely that developing such an interface is not trivial, but will not form part of this project. Once the topic is chosen the system will select the feature classes to include in the map.

> *For topographic maps it is reasonable to assume that all the required information is in the database and is classified appropriately. For special topic maps the special topic information may either be in the same database as the topographic information or stored separately. How topic information is handled is a major consideration in developing a complete map design expert system, but as the aim here is to select appropriate topographic base information the availability and classification of the topic information is of no concern.*
>
> (Forrest, 2003, p.8)

3.3 What information is needed to solve the problem?

Following decisions on location, scale, format and level of detail required, the next stage is selection of the data that we will organize in our design. Thus, how the data are chosen to serve the purpose and to be suitable for the scale of the map must be considered.

In traditional map production the background topographic information is typically derived from the available topographic maps. Selecting features or layers from existing maps will make achieving different levels of detail possible, but is time consuming. GIS and geospatial databases may have a menu of layers that the author can include in the map; any feature class can be chosen by checking a box that appears on the screen and this feature will appear on the map. If there are only a few layers in the database the map author will not need to spend much time in selecting base information. However, in many cases, particularly at larger scales, there may be many layers, each with potentially many different classes of feature. In such cases, the time and knowledge required to make the most appropriate selection will be significant. For example: in a 1:1,000,000 scale database the transport layer may only include the main roads, while in a 1:24,000 scale database this layer may include 5^{th} or 4^{th} importance roads as well.

With the aim of building a knowledge base about map content, data has been collected from maps on various topics and at different scales. This collection has been done by recording the content of a wide range of existing

maps and atlases. The data collected on map content will be used to create a knowledge base by analysing it by scale and by topic. This will help to give a clear view about the map contents and how it changes when changing the scale or the topic.

An alternative approach to data collection is to ascertain what those producing and using maps think is the appropriate content for maps on a range of topics and scales. This could be done by interviewing appropriate experts, or, as done here, by questionnaire. This questionnaire has been sent to expert cartographers and map users with various experience and cartographic background.

Having two different, independent, sources of data will allow a comparison of what is predicted to be the appropriate content of particular maps, may allow anomalies in either dataset to be highlighted and should result in a more robust final knowledge base.

3.4 How the knowledge base will be used?

Previous work by Forrest and by Richardson suggest ways in which such knowledge on map content could be used. Both of these earlier studies looked at smaller scale maps, both using a base scale of 1:2,000,000 compared to the base scale of 1:250,000 used here.

Deciding which feature classes to include depends on the topic of the map. One approach is to score the feature classes depending upon the desirability of them being included in a map on a particular topic. This score could range from zero to ten. Ten means the feature is always included in the map, while zero means the feature would never be included in a map of that topic (Forrest, 1999). For example, national boundaries virtually always appear on maps regardless of scale and topic, so the score for them will be ten for all topics. Sub district boundaries are unlikely to be included in a geological map, so the score will be zero in this case. For a map topic where county boundaries are sometimes included in the map, the score range will be between one and

nine. In an automated system, those features with scores for the selected map topic equal to or greater than a calculated selection index value will be included; those with scores below this selection index will be excluded.

In a semi-automated solution, the scores could be used to make an ordered list of feature classes that could be included in the map. The author could then select features from this ordered list. But if the list has too many classes then the author may overlook some classes. Such a system operates as an "intelligent assistant" not as a fully automated system. This approach could also be used when the map author is not satisfied with the automated selection and wishes to subsequently edit the list of contents.

The main focus of this research is to use Forrest's method of calculating the selection index, compare it with the inclusion scores based on the knowledge base created using the existing map data and select the appropriate features. The features will then be selected in a GIS to produce a series of example maps. The features selected using this approach will also be compared to those indicated by the questionnaire results and their selection using Richardson's approach.

3.5 Conclusion

A cartographic expert system provides guidance on map design, compilation, and reproduction. The purpose of this system is to help the user to describe the type of map required and decide the cartographic specifications needed for the map. One particular element of this, automating the selection of the map content, is the main aim of this study using an expert system approach. To have a good result from the expert system the first step should be building a good knowledge base. This knowledge base will help in classifying and selecting the contents of the map. In order to automated the selection process, the next step must be determine the relevance of the range of topographic information in a database to maps in various topic categories. This could be done by reclassifying the collected data, and selecting the necessary features and sub features related to the map topic and map scale, entered all these features into

GIS program and produce a new map. Classifying and selecting features is the focus of chapter 4.

Chapter 4
Building the Knowledge Base

4.1 Introduction

Any information systems is only as good as the data it contains. The data in a GIS describes spatial phenomena and can be extracted and manipulated to create maps. The initial stage in map production from such a database is the selection of data to provide appropriate content for the particular map topic. To aid this selection it is important that data is classified in a suitable way and thus there is a clear link between selection and classification.

Following discussion about the data and its classification in the database, this chapter then focuses on building the knowledge base required to automate the selection of appropriate base information from the database for different map topics.

4.2 Classification

Classification is the basis of communication. It makes distinctions between groups of things and attaches labels to the classes. It is an artificial concept and often there will be various ways of classifying the same data. Care needs to be taken to ensure the classification fits both the nature of the data and the purpose of its use.

Classification is central to mapping. It will group data to be mapped into relatively small number of categories. Most often the mapmaker will start work with information that has already been classified in some way. In addition, mapmakers use classification to reduce their maps' complexity. This reduction in complexity will help both mapmaker and map user. In classification, the mapmakers should decide how many classes they will use. They must then determine the limits of the class. They should determine the beginning and the end of each group, like a boundary between vegetation and non-vegetation groups. Most boundaries between classes are artificial. Thus various methods of

determining the classification will give different maps, even when the same information is used.

For each situation, there are many possible classification and reclassification methodologies. All these possibilities depend on the GIS and the needs of the user. In life, we wear different types of clothes, drive different kinds of vehicles, and so on. Thus, the classifications are designed to put people, things, and places in different groups. For cartography, classifying the Earth's surface into features is very important. This will show us how the map should be organized, and how the cartographer will group features by physical types, political division and by human endeavour. For example, land classification will depend on the types of objects that will be grouped together. There are different classifications for vegetation, agriculture, land use, land cover, and so on. The scale of the map affects all types of classifications. For example, a vegetation classification that is suitable for mapping the whole Earth is unlikely to be suitable for mapping a small region. Also, classification will be affected by the technology that used in collecting data, such as using satellite remotely sensed data compared to a survey on the ground.

All types of classification have one thing in common. They have one aim which is an audience or user in mind. In some classified data sets the end user will be very specific. The more closely the classification can be made to fit the user needs, the more useful this classification will be. Classification can be done within a GIS because GIS provides a variety ways to classify and reclassify the stored data. Furthermore, the GIS operator can display the existing classification or manipulate the existing attributes which help in making classification more usable in answering the questions that will be used in making decisions.

In their feature classification, the Canadian national standards for the exchange of digital topographic data give a good example. This classification includes four levels. Level 1 uses ten major classes: designated area, building, structure, roadway or railway, utility, delimiter, hydrography, hypsography, land cover, and textual information. In level 2, each one of these classes is divided into categories. Level 3 is an alphabetical listing of all features which will be used

in topographic maps. Level 4 divides each feature in level 3 by attributes (Forrest, 1999).

Database organization is a very important task when flexibility of use is required. For easy of use, map models have many layers. For example, according to Arctur and Zeiter (2003) the current national map layers for the United States include: reference (map grids or graticules), transportation (roads, railroads, airports), administrative (boundaries), hydrography (surface water, drainage networks), surface overlays (land cover or vegetation, soil type, and surface geology), cultural (regional centres, urban areas, school, and hospital), hypsography (contours, spot elevations, DEM), image base (orthoimagery and satellite imagery) page layout design (legend, source attribution). Each layer may have several main classes of features. For each feature class the dataset will be grouped into sub classes. The following chart, figure 4.1, shows all layers for topographic information based on the US National Spatial Data Infrastructure.

Figure 4.1. Possible organization of base map layers (after ESRI, 2003)

Maps of different topics at different scales will contain different contents. This could make a GIS user confused when trying to make a map. Thus an Expert System taking control of the map contents could make using GIS easier and faster. Building a good and wide knowledge base about the map contents is needed to do this. This knowledge base should cover a variety of map topics and a range of scales. Applying this knowledge effectively should producing a good, clear map with minimal input from the GIS user.

4.3 Creating a knowledge base

4.3.1 Map layers

Typically map data within GIS is organized in layers. Each layer will contain one type of information for the map area. In this cartographic model, one layer may cover roads, another layer could include soil types, a third show buildings, while a fourth layer gives land cost, and so on. Also a map layer should include (or be linked to) metadata to describe its nature, its source, its reliability, and so on. Thus, a map layer is a set of data describing the spatial variation in one characteristic of a geographic study area.

For this study map features will be classified with up to four levels: Layer, feature class, sub-feature class, and sub-sub-feature class. For example, in the transport layer, there could be four feature classes: road, railway, ferry, and airport. Each feature may have many sub-features or classes. The road feature class may have motorway, primary route, A road, B road, minor roads and additional road features. Also each one of these sub-classes has sub-sub-features (sub-classes). But not all classes have sub-classes. In some cases classes and sub-classes are stored as attributes of features but it is possible to create the four level hierarchies described from such information. The background of this classification is the information that has been collected from the existing maps at scales between 1:250.000 and 1:1000.000 for a variety of topics and the existing classification of the data used in this study.

4.3.2 Ordnance Survey data

Ordnance Survey is the National Mapping Agency for Great Britain. It has been providing accurate, reliable and detailed maps and geographic information for over two hundred years. Ordnance Survey provides digital information in several formats at different national scales from 1:1250 to 1: 650.000.

4.3.2.1 Strategi data

Strategi data is a digital topographic data set for England, Wales, and Scotland. Strategi data has been digitised from maps published by the Ordnance

Survey at 1:250 000 scale. Strategi data is updated annually. Each update is a replacement dataset for all data (Edina, 2007).

Strategi data is defined as a limited link and node database. In this dataset the geographical features are points, or lines. Points represent individual point entities, or name placement locations. Line features include linear entities such as roads, railways and rivers and the boundaries of area features, such as lakes.

All Strategi features are classified by feature codes. These codes give each feature a specific category and allow the user to group all the features for search or output routines. Each feature code has one or more associated attribute. These attributes give the entities of points, or lines meaning. This is because attributes represent and describe the characteristic of an entity of the feature like a name or a numerical value.

All Strategi data are grouped into layers and features. Table 4.1 shows all these data and their feature codes.

Table 4.1. Ordnance Survey Strategi data

OS strategi data				
Layer	Feature	Sub- features	feature code	graphic type
Communication	Motorway	Motorway normal	5310	Line
		Motorway tunnel	5313	Line
		Motorway u/c	5300	Line
		Motorway over	5312	Line
		Motorway junction limited	5371	Point
		Motorway junction u/c	5372	Point
		Motorway junction	5370	Point
	Primary route	Primary route d/c	5320	Line
		Primary route d/c, over	5322	Line
		Primary route d/c, u/c	5302	Line
		Primary route roundabout, d/c	5355	Point
		Primary route, s/c	5323	Line
		Primary route, s/c, u/c	5304	Line
		Primary route, s/c, over	5325	Line
		Primary route roundabout, s/c	5375	Point
		Primary route narrow	5326	Line
		Primary route narrow, over	5327	Line
	A road	A road narrow	5336	Line
		A road narrow over	5337	Line
		A road d/c	5330	Line
		A road d/c over	5332	Line
		A road d/c, u/c	5306	Line
		A road roundabout, d/c	5356	Point
		A road s/c	5333	Line
		A road s/c, over	5335	Line
		A road s/c, u/c	5308	Line
		A road roundabout, s/c	5376	Point
	B road	B road s/c	5343	Line
		B road s/c, over	5345	Line
		B road s/c, roundabout	5377	Point
		B road d/c	5340	Line
		B road d/c, over	5342	Line
		B road d/c roundabout	5357	Point
		B road narrow	5346	Line
		B road narrow, over	5347	Line
	Minor road	Minor road	5350	Line
		Minor road, over	5351	Line
		Minor road roundabout	5374	Point
	Railway	Railway standard	5510	Line
		Railway standard, over	5511	Line
		Railway narrow	5512	Line
		Railway narrow, over	5513	Line
		Railway tunnel	5514	Line
		Railway station	5520	Point
	Airport	Airport with customs	5839	Point

		Airport without customs	5840	Point
		Heliport	5845	Point
	Ferry	Ferry, vehicular	5390	Line
		Ferry, route link	5393	Line
	Footpath	Footpath	5825	Line
	Additional road features	Multilevel junction	5379	Point
		Multilevel junction, u/c	5378	Point
		Gradient	5380	Point
		Toll	5382	Point
		Level crossing	5530	Point
		Motorway services under construction		Point
		Motorway services limited		Point
Boundary	Boundary	County boundary	5720	Line
		National, forest park boundary	5820	Line
		National boundary	5710	Line
Water feature	Coast	Coast	5110	Line
	Sea area seed	Sea seed	5115	Point
	Lake	Lake, seed(inland)	5251	Point
		Lake, margin (inland)	5250	Line
	Canal	Canal tunnel	5241	Line
		Canal, over	5242	Line
		Canal	5240	Line
	River	Main river source	5211	Line
		Main river middle	5212	Line
		Main river lower	5213	Line
		Secondary river source	5221	Line
		Secondary river lower	5222	Line
		Minor river	5230	Line
	Foreshore area	Foreshore, other, margin	5495	Line
		Foreshore, sand, margin	5494	Line
		Foreshore, other, seed	5123	Point
		Foreshore, sand, seed	5121	Point
	Lighthouse	Lighthouse in use	5140	Point
		Lighthouse disused	5142	Point
	Lightship	Lightship	5141	Point
Settlements	Settlements	Primary route destination		Point
		Not primary route destination		Point
		City	5427	Point
		Town	5413	Point
		Village	5416	point
		Land mark	5419	Point
	Urban area	Small urban area, margin	5422	Line
		Small urban area, seed	5423	Point
		Large urban area, margin	5420	Line
		Large urban area, seed	5421	Point
Land use	Geographical area seed	Geographical area seed	5620	Point
	Woodland	Woodland margin	5610	Line
		Woodland seed	5611	Point
	Marsh	Marsh	5612	Point

Other feature	Windmill	Windmill	5844	Point
	Antiquities	Roman road	5810	Line
		Hill fort	5815	Point
		Battlefield	5816	Point
	Tourist	Castle	5877	Point
		Historic houses	5878	Point
		Battle site		point
		Information centre	5866	Point
		Youth hostel	5868	Point
		Camping- caravanning	5861, 5862	Point
		Zoo	5870	Point
		Museum- theatre	5864	Point
		Skiing centre	5884	Point

4.3.3 Organizing the map layers and description of contents

There are some problems with the Ordnance Survey classification in that there is no clear definition for some features and in some cases the classification if more extensive than required. For example, rivers are classified in Strategi as main river source, main river middle, main river lower, secondary river source, secondary river lower and minor river. For the purposes of data selection a distinction between major, secondary and minor rivers is all that is required. In Strategi, all lakes are in the same class, whereas it would be useful for selection purposes to distinguish between large and small lakes.

Another major problem is with settlement features. There is no clear definition for each sub-feature in this layer. Cities are divided into primary route destination and not primary route destination, but for selection purposes there needs to be a clear definition for each sub-feature like city, town, and village according to the population of the area or some other criteria.

Although the O.S. Strategi data provides a basis for this project, the overall objective is to produce a generic knowledge base that could be applied to different source datasets. Thus, for this study the map contents have been classified into seven main layers: hydrology layer, boundary layer, land use layer, relief layer, transportation layer, settlement layer and cultural layer. This is shown in more detail in Table 4.2 and discussed below.

Table 4.2. Showing the map contents by dividing it into layers, features, sub-features, and sub-sub-features.

Layer	Feature-class	Sub-feature-class	Sub-sub-feature-class
Hydrology	Lake	Major lake	
		Minor lake	
	River	Main river	
		Second class river	
		Minor river	
	Canal	Major canal	conduit
		navigable canal	
		non navigable canal	aqueduct
		tunnel	
	Other water features	Marsh and swamp	
		Spring. Well, cistern	
		Glacier	
		Dam	
Boundary	Administrative	National	
		County	
		State	
		District	
	Others	National forest park	
Landscape Features	Land cover	Wood/forest	
		Rock	
		Sand dunes	
		Mudflat	
		Foreshore area	
	Topographic features	Power line	
		Mine	
		Ruin	
		Lighthouse	
		Lightship	
		Windmill	
		Wind pump	
Relief layer	Height	contour	contours
			submarine contours
		Spot height	
	Minor features	Mound	
		Cliff, slope	
Transportation	Roads	Motorway	Normal motorway
			Under construction
			Motorway tunnel
			Motorway junction
			Full or limited motorway access
		Primary route	Dual carriageway
			Single carriageway
			Under construction route
			Tunnel
		A road	Dual carriageway
			Single carriageway
			Under construction road

			Narrow road
		B road	Single carriageway
			Dual carriageway
			Narrow road
		Minor road	Unclassified road
			Other roads
		Additional road features	Gradient and steep
			Toll
			Footpath, trail
			Bridge
	Rail network	Standard railway	Single
			Double
			Multiple
		Narrow railway	Single
			Double
			Multiple
		Railway tunnel	
		Railway station	
		Tourist railway	
		Disused railway	
	Airport	Airport	
		Airfield	
		Seaplane port	
		Heliport	
	Ferry	Vehicular ferry	
		Ferry route link	
		Passenger ferry	
Settlements	City	Capital, city	
	Town	Large	
		Small	
		Other town	
	Village	Large	
		Small	
	Built up area	Large urban area	
		Small urban area	
	Isolated group of buildings		
Cultural	Public	School	
		Hospital	
		Cathedral	
		Parks and garden	
		Towers	
		Landmark	
		Power line	
		Telephone call box	
	Tourist	Castle	
		Historic houses	
		battle site	
		information centre	
		Youth hostel	
		Camping -caravanning	

		Zoo	
		Museum- theatre	
		Skiing centre	
		National forest park	

1. Hydrology layer

This layer covers all hydrological features. It has a rich classification, and includes point, line and area data. Thus, this layer includes all water surfaces and managing water surfaces. In this classification the hydrology layer has been divided into five main classes and many minor sub-feature classes.

The main classes in this layer are lake, river, coastline, canal, and other water features. The lake class includes two sub-classes, main lake and minor lake. The difference between these sub features is based on the lake's area:

Major lake area > 1 cm^2 at the base scale;

Minor lake area < 1 cm^2 at the base scale.

The second class is river, which includes major, second class, and third class rivers. The definition for these sub-classes is:

Major River: navigable river;

2^{nd} class river: non-navigable, significant river;

Minor River: non-navigable river, small river.

Also canal as a main class includes: major canal, navigable canal, and non-navigable canal or channel.

All other features which are related to the water surface, or to water management, will be included in the last main class 'other water feature'. These sub-classes include marsh and swamp, spring, well and cistern, glacier, dam, and so on.

2. Boundary layer

Usually, boundaries are used for distinguishing between different countries, states and other administrative areas. This layer could include a very broad sets of classes. Features in this layer include district and sub-district

boundaries, national boundary, national forest park boundary, county boundary, state boundary, and so on.

3. Landscape layer

This layer includes different types of features under two main classes: land cover, and landscape features. Land cover class includes wood forest, foreshore area, rock, mudflat, sand dunes and others. Landscape or topographic features include point and line features. These features could be power line, mine, ruin, lighthouse, lightship, and so on.

4. Relief layer

Relief layer is one of the most distinctive elements of the base map. This layer adds a lot of important information to the map like contour lines, hill shading, spot heights and many others. This layer could be divided into two main classes: main relief, and minor relief. The first class could include contours, trigonometric point. While the second class has features like mound, cliff and slope, and so on.

5. Transportation layer

Transportation data is very important for urban and regional planning, emergency, travel and general purposes. Most maps show the at least some of the road network, and many include the rail network, ferry links and airports.

- Road feature classes: in this class all roads are divided into six sub classes. Theses sub-classes are motorway, primary route, A road, B road, minor road, and additional road features. Each of these sub-classes has sub-sub-classes.

Roads can be classified in many different ways. This will depend on the type or the purpose of the map, but broader discussion of this is beyond the scope of the current study and a classification based on the UK system as exemplified by the test data is adopted.

• Rail network: a railway feature model includes five sub-features classes. These classes are standard railway, narrow gauge railway, railway tunnel, railway station, and tourist railway. Some of these sub-classes, like standard and narrow railway, have three sub-sub-classes, which are single, double, and multiple tracks.

6. Settlements layer

This layer gives the map user important information about the populated places. Thus this layer could be divided in a number of ways depending upon information available. In this case it has been divided into four main features: city, town, village, and isolated group of buildings. This division depends on the population. The population for each feature adopted is:

City: more than 200.000;

Town: 5000 – 200.000;

Village: 200 – 5000.

Isolated group of buildings: settlement or small group of buildings significant in landscape or of administrative importance.

Some of these features like town and village will include sub-classes.

Town:	Large town: 50.000 – 200.000;
	Small town: 5000 – 50.000 ;
Village:	Large village: 1000 – 5000 ;
	Small village: 200 – 1000.

7. Cultural layer

This layer depends on the data model and it is intended to include all significant features which are used in topographic maps and are not included in any other layers. This layer is divided into two classes public or government features and tourist features.

Public features include schools, hospitals, cathedrals, parks and gardens, towers, landmarks and telephone call box. Tourist features includes castle, historic houses, battle site, information centre, youth hostel, camping and caravanning, zoo, museum and theatre, skiing centre and so on.

4.4 Structuring and building the knowledge base

Having developed a structure for the database, the next step is to create a knowledge base that allows the appropriate information to be selected for maps of different topics. The knowledge required to build the knowledge base will be collected in two ways. The first way is by examining the topographic base information included in existing maps. These maps are produced at scales between 1:250 000 and 1:1000 000 and cover a wide range of topics: topographic, political, population, land use, relief, land cover, climate, communication, and environmental science. All the data collected is divided into two groups. Data in the first group was collected from maps with different scales and same topic. In the second group the maps are of different topics, but at the same scales. The second method of collecting data was by sending a questionnaire to cartographic and map topic experts. The questionnaire covers the same range of topics and scales as the first method.

4.4.1 Existing maps and atlases

Collecting data on topographic base information in the first way has been done for 157 maps and from 11 atlases on nine different topics (see appendix A for map and atlas details). By collecting these data, the difference between the maps' topographic base contents can be assessed. This difference usually depends on the map topic and map scale. Map contents are divided into layers, and each layer divided into feature classes and sub classes. All maps have the same layers but the contents of these layers changes from one map to another.

Typically, when the map scale is changed many of the feature classes will continue to appear, but the sub-classes within it will change. For example, the transportation layer has many feature classes, one of which is roads. When changing map scale from 1:250.000 to 1:500.000 we still have this feature class but the sub-feature classes included will generally reduce. For example, all maps at scales from 1:250.000 to 1:1000.000 include 'A roads' as sub-class feature, but at different percentage. 56.1% of maps at scale 1:250.000 include 'A roads' while 32.35% of maps at scale 1:1000.000. Sub-sub-classes are not included in

the maps at different scales. 'A roads single carriageway' is included in maps at 1:250.000 and 1:500.000 but at different percentage, while it is not included in maps at 1:1000.000. Table 4.3 shows the sub and sub-sub-feature classes percentage shown at different scales. These percentage have been calculated regarding to the number of appearance for the feature in the collected data.

Table 4.3. Feature classes present at various scales.

Layer	Feature class	Sub-class	Sub-sub-class	1:250 000	1:500 000	1:1000 000
Transport	Roads	A road		56.1 %	44 %	32.35 %
			Single carriageway	2.44 %	12 %	0 %
			Dual carriageway	9.76 %	10 %	10.29 %
			Under construction	4.88 %	12 %	7.35 %
			Narrow road	2.44 %	2 %	1.47 %
		B road		56.1 %	40 %	30.88 %
			Single carriageway	0 %	0 %	0 %
			Dual carriageway	7.32 %	6 %	1.47 %
			Narrow road	7.32 %	2 %	0 %
		Minor road		7.32 %	10 %	2.94 %
			Unclassified road	2.44 %	14 %	0 %
			Other roads	51.22 %	24 %	20.59 %
		Additional road features	Gradient, sleep	14.63 %	16 %	0 %
			Toll	14.63 %	16 %	1.47 %
			Footpath, trail	24.39 %	4 %	19.12 %

For different map topics at the same scale, classes may also have many sub-classes. The presence of features within the classes and sub-classes will change for different map topics. For example large towns could be found in maps of most different topics, but at different percentages, while small towns cannot be found in many map topics. Table 4.4 shows that some classes disappear in moving from one map topic to another.

Table 4.4. Map topic and feature classes

(* indicates this feature is likely to be present).

Layer	Feature class	Sub-class	Climate	Environmental	Relief	Communication	Land use	Population	Topography	Political	Land cover
Settlements	City		*	*	*	*	*	*	*	*	*
	Town	Large	*	*	*	*	*	*	*	*	*
		Small		*	*	*		*	*	*	*
		Other		*		*		*	*	*	*
	Village	Large	*	*	*	*		*	*	*	*
		Small			*	*		*	*	*	*
	Urban area		*	*	*	*	*	*	*	*	*
	Landmark					*			*		

These two examples show that changing scale, or map topic significantly affects the contents of the map. Thus the relationship between map topic, map scale, and the map content is clear.

The maps studied covered a wide range of map topics and Appendix B shows all the data collected for the range of scales and topics examined. The contents of these maps highly depend on the topic. Depending on the appearance of each class of feature in each map a percentage has been given for each map topic. Thus each feature has a different percentage for each topic. Some features like city always have a high percentage for all studied topics, while village, which is a feature in the same layer, has a varying percentage which varies from 0% in land use maps to 100% in population maps. In another layer, major river also has a presence of between 25% in climate maps and 100% in relief and population maps. Motorway feature has a high percentage in communication maps, 92%; while it's lowest percentage related to the population maps at 22%. In topographic and relief maps, all topographic features should have a high percentage. In topographic maps these features have a percentage between 30% and 60%, while in relief maps the percentage is between 13% and 100%. Table 4.5 shows the full details of the presence of features on existing maps.

Using these percentages the knowledge base has been developed by classifying the presence of features into six groups: never required, rarely required, occasionally required, sometimes required, usually required and always required. Each group is assigned an 'inclusion score' in the range 0 to 10. These scores show how the map content will vary from one topic to another, and how the same feature will have the different scores for different topics. For example, large town has a score 10 in population maps and 4 in land use map. Table 4.6 shows the selection scores for various map topics.

By looking at the scores in this table, a number of inappropriate scores can be found. For example, coastline is a very important feature for most map topics, thus this feature should have score 10 for all topics, but it has scores from 10 to 4. Furthermore, rivers and lakes are main features in topographic maps. These features should have a high score for this map topic, but the selection score for river is 8 and for lake is 6. These problems have occurred because some of the data has been collected from examples of existing maps that did not have a coastline, lake or river. That is why this table should be compared with another source then modified to give a more appropriate selection score that will help in the correct selection features in map production. In other words the knowledge of an expert needs to be used to apply a first order correction to the knowledge base.

Table 4.5 Presence of features on existing maps (percentage)

Feature sub-class	Sub-sub-class	Topographic	Political	Population	Land use	Relief	Land cover	Climate	Communication	Environmental science
Limited access highways (motorways)	Carriageways	80.00%	72.00%	22.00%	64.00%	50%	64.00%	50%	92.00%	41.00%
	Junction/ slip road detail	49.00%	43.00%	0%	45.00%	50%	50%	50%	31.00%	32.00%
Major road	Key primary routes	54.00%	57.00%	11.00%	18.00%	50%	50%	50%	47.00%	23.00%
	All dual and single carriageway	67.00%	14.00%	0%	18.00%	25%	0%	25%	81.00%	18.00%
Secondary road	Secondary roads	62.00%	14.00%	0%	9.09%	13.00%	0%	25%	83.00%	14.00%
Minor road	Other road (surfaced)	49.00%	14.00%	0%	0%	13.00%	0%	25%	56.00%	14.00%
	Unclassified road or track	0%	0%	0%	0%	0%	0%	0%	22.00%	0%
Additional road Features	Gradients- steep	5.00%	0%	0%	0%	0%	0%	0%	33.00%	0%
	Toll	5.00%	0%	0%	0%	0%	0%	0%	33.00%	5.00%
	Footpath, trail	49.00%	0%	0%	0%	0%	0%	0%	11.00%	5.00%
Water feature	Major lake	77.00%	43.00%	78.00%	82.00%	100%	71.00%	75%	94.00%	82.00%
	Minor lake									
	Canal	31.00%	7.00%	0%	18.00%	38.00%	0%	0%	39.00%	41.00%
	Major river	88.00%	57.00%	100%	82.00%	100%	93.00%	25%	97.00%	91.00%
	2nd class river	59.00%	36.00%	89.00%	64.00%	88.00%	86.00%	25%	58.00%	60.00%
	3rd class river									
	Large area of marsh or swamp	62%	0%	11.00%	18.00%	13%	29%	0%	8.00%	5.00%
Settlements	City	100%	93.00%	100%	100%	88.00%	86.00%	100%	100%	87.00%

	Town	85.00%	86.00%	100%	36.00%	63.00%	57.00%	100%	89.00%	73.00%
	Village	44.00%	50%	100%	0%	38.00%	21.00%	25%	58.00%	23.00%
	Isolated group of buildings	46.00%	57.00%	56.00%	82.00%	63.00%	64.00%	50%	50%	46.00%
Boundary	National boundary	74.00%	79.00%	67.00%	36.00%	50%	64.00%	50%	72.00%	64.00%
	First level internal boundary	41.00%	79.00%	33.00%	9.00%	25%	21.00%	50%	58.00%	46.00%
	Second level internal boundary	26.00%	57.00%	44.00%	18.00%	13.00%	14.00%	75%	19.00%	18.00%
	Coastline	38.00%	64.00%	100%	73.00%	75%	86.00%	100%	89.00%	95.00%
	National or regional park	18.00%	7.00%	0%	9.00%	13.00%	7.00%	25%	28.00%	0%
Land cover	Wood / forest	33.00%	7.00%	11.00%	55.00%	0%	29.00%	0%	28.00%	9.00%
	Plantation or cultivated area									
	Extensive non vegetated area									
Other features	Major historic/ cultural site	8.00%	0%	0%	9.00%	0%	0%	0%	14.00%	0%
	Landmark	13.00%	0%	0%	0%	0%	0%	0%	0%	0%
Topographic Features	Key spot heights	41.00%	14.00%	11.00%	0%	13.00%	0%	50%	11.00%	14.00%
	General relief information	62.00%	21.00%	0%	0%	100%	14.00%	25%	8.00%	27.00%
	Detail height information	33.00%	7.00%	0%	0%	25%	14.00%	50%	31.00%	5.00%
Transport	Vehicular ferry	23.00%	7.00%	0%	0%	0%	14.00%	0%	67.00%	5.00%
	Passenger ferry	21.00%	7.00%	0%	0%	0%	7.00%	0%	6.00%	0%
	Main line railway	56.00%	57.00%	0%	0%	13.00%	21.00%	25%	44.00%	27.00%
	Other railway	41.00%	7.00%	0%	0%	0%	7.00%	0%	31.00%	14.00%
	Airport	51.00%	21.00%	0%	9.00%	13.00%	14.00%	0%	72.00%	5.00%
	Harbour	21.00%	0%	0%	0%	0%	14.00%	0%	3.00%	0%

Table 4.6 Selection (Inclusion) scores for various map topics

Features	sub features	Relief	Communication	political	topographic	land use	Population	Land cover	Environmental	Climate
motorways	normal	4	8	6	6	6	2	6	4	4
	motorway tunnel	0	4	0	0	0	0	0	0	0
	motorway junction	4	6	6	4	4	0	6	4	4
primary route	primary route	4	6	6	6	4	2	6	2	4
a roads	main road	2	8	2	6	2	0	0	2	2
b roads	secondary roads	2	8	2	6	2	0	0	2	2
	other road	2	6	2	6	0	0	2	2	2
railway	standard	2	6	6	6	2	0	2	4	2
	narrow	0	2	0	4	0	0	0	0	0
	railway tunnel	0	4	2	4	0	0	2	2	0
	railway station	0	4	2	4	0	0	0	2	0
	tourist railway	0	2	0	2	0	0	0	0	0
water feature	lake	10	8	6	6	8	8	8	6	6
	tunnel	2	0	0	0	0	0	0	0	0
	canal	4	6	2	4	2	0	0	4	0
	vehicular ferry	0	6	2	4	0	0	2	2	0
	ferry route link	0	2	0	0	0	0	0	0	0
	river/ main	10	10	6	8	8	10	8	8	2
	2nd river	8	6	4	6	6	8	8	6	2
settlements	city	8	10	10	8	10	10	8	6	8
	town	6	8	8	8	4	10	6	6	8
	2nd town	2	6	6	6	0	10	2	2	0
	other town	0	4	2	6	0	6	2	2	0
	village	4	6	6	6	0	10	2	2	2
	small villages	2	4	4	4	0	8	2	0	0
	urban area	6	6	6	6	8	6	6	4	4
boundary	national boundary	4	8	8	6	4	6	6	6	4
	county boundary	2	6	8	6	2	4	2	4	4
	state boundary	2	4	6	4	2	4	2	2	6
	national forest park	2	4	0	2	0	0	2	0	2
	coastline	6	8	5	4	6	10	8	8	8
	national park	0	4	2	4	2	0	2	0	0
land use	wood forest	0	4	2	4	6	2	4	2	0
	airport	2	8	4	6	2	0	2	2	0
topographic	point(spot heigh)	4	4	2	6	0	2	0	2	4
features	distance	2	4	0	4	0	0	0	0	0
	submarine contours	0	2	0	2	0	0	0	0	0
	contours	6	2	4	6	0	0	2	4	2
	height	2	6	2	4	0	0	2	4	4

a score of 10 implies always select/include; a score of 0 implies never select/include)

4.4.2 Questionnaire survey

Everybody has a different view about map content, which depends on their cartographic background and knowledge about the map's topic. The background of cartographic knowledge varies widely among map users. The map user could have little knowledge, or could be an expert in using maps. The map designer or producer, who should be an expert in using maps, has a clear understanding of map content, but often is not an expert in the map topic. An experienced cartographer should be aware of how much changing the scale and topic will affect these contents. This experience in using maps and making decisions about their content cannot be assumed for many map makers.

In order to confirm the knowledge gathered from the examination of existing maps, a questionnaire was sent to cartographers and map users with wide range of background and cartographic knowledge. This questionnaire covers nine different map topics: topographic, political, population, land use, relief, land cover, climate, communication, and environmental science. Responders were asked to divide the map contents into four types: E, D, Q, and U for different topics and scales:

E: essential features. These features are needed to support the map contents.

D: desirable. Features in this group are not essential but useful in describing the map contents.

Q: questionable. Features in this group could be used but are not necessary to understanding of the map.

U: unnecessary. Features are unnecessary or unusable in the map

(See appendix C for full details of questionnaire).

This questionnaire has been sent to variety of experience people with different background of cartography. Their experiences vary from designing maps to normal reader. They all have been asked to give their own opinion about the basic contents regarding to topic ands scale of map.

For designing the best map the view of the expert user gives a good idea about the map contents. By collecting and comparing their views a big difference has been found. For example, national boundary as a feature in the boundary layer and for the same map topic, some of the responses said it is essential and others said it is desirable. Despite sending the questionnaire and reminders to a wide range of cartographers and map topic experts only seven replies were received. This is very disappointing. Giving a percentage to all the collected data helps in making a decision about the majority view for each feature. For example, for communication maps 100% of experts said the motorway is an essential feature in this type of map. While the same feature in relief map has a wide variation in response making a decision to chose one value difficult: E: 14%, D: 14%, Q: 29% and U: 43%. In this case the category with highest percentage response should be chosen. In another feature making a decision is too difficult when more than one category has the same percentage, as in major roads for land cover maps, where three groups have the same percentage: E, Q and U: 29%. Which category should this feature be assigned to? This problem has been found for different map topics and for different features. Table 4.7 shows all features that have a percentage more than 40% for each feature for different map topics, indicating cases where there is reasonable agreement amongst the experts. Appendix F shows the full responses for different map topics. All the calculated percentages have been done regarding to the experts chosen for each feature and each group.

Table 4.7 Questionnaire results for different map topics.

Feature-class	Sub-class	Topographic	Political	Population	Land use	Relief	Land cover	climate	communication	Environmental science
Limited access highways (motorways)	carriagways	E: 86%	E,D: 43%	D,U: 43%	E,D: 43%	U:42.85%	E,D: 43%	U: 57%	E: 100%	D: 57%
	Junction/ slip road detail		U: 57%	U: 57%	Q,U: 43%	U: 71%	U: 57%	U: 71%	U: 57%	U: 57%
Major road	Key primary routes	E: 86%	D: 57%	U: 43%	D: 43%	U: 43%	E: 43%	U: 57%	E: 100%	D: 57%
	All dual and single carriageway	E: 57%	Q: 43%	U: 57%	Q: 57%	U: 57%		U: 71%	E: 86%	Q: 43%
Secondary road	Secondary roads	E: 57%	U: 43%	U: 57%	Q: 43%	U: 57%	Q: 43%	U: 71%	E: 71%	
minor road	Other road (surfaced)	E: 43%	U: 43%	U: 71%	U: 43%	U: 57%	U: 57%	U: 71%	E: 43%	U: 57%
	Unclassified road or track	Q: 43%	Q, U: 43%	U: 71%	U: 57%	U: 57%	U: 57%	U: 71%	D: 43%	U: 57%
Additional road Features	Gradients- steep	Q: 43%	U: 86%	U:100%	U:43%	U:43%	U:71%	U:71%	D: 43%	U: 43%
	Toll	U:43%	U:86%	U:100%	U:71%	U:86%	U:86%	U:86%	E: 43%	U: 71%
	Footpath, trail	D: 57%	U: 57%	U: 86%	U: 57%	U: 57%	U: 71%	U: 86%	D: 43%	Q,U: 43%
Water feature	Major lake	E: 100%	E: 57%	E,D: 43%	E: 100%	E: 86%	E: 100%	E: 71%	E: 100%	E: 100%
	minor lake	E: 71%	Q: 43%	Q: 43%	E, D:43%	E,Q: 43%	E: 71%	U: 43%	E: 43%	D: 71%
	canal	E: 71%			D: 57%	D:43%	D: 57%	U: 43%	E: 57%	D:86%

	Major river	E: 100%	D: 57%	D: 57%	E: 86%	E: 71%	E: 86%	E: 43%	E: 86%	E: 100%
	2nd class river	E: 71%	Q: 57%	U: 57%	E: 57%	E: 71%	E: 57%	U: 43%	E: 57%	E: 57%
	3rd class river	D: 43%	U: 71%	U: 86%	Q: 43%	E: 43%	D: 57%	U: 57%	E,D,Q: 29%	D: 57%
	Large area of marsh or swamp	E: 86%	U: 71%	U: 71%	E: 71%	D: 57%	E: 86%	D: 43%	E,D: 43%	E: 71%
Settlements	City	E: 86%	E: 86%	E: 86%	E: 100%	E: 71%	E: 86%	E: 71%	E: 100%	E: 71%
	town	E: 57%		E: 57%	E: 86%		E,D: 43%		E: 71%	D: 57%
	village	E,D: 43%	U: 43%	D: 43%	D: 57%	U: 57%	Q: 43%	U: 86%	D: 43%	Q: 57%
	Isolated group of buildings	D,U: 43%	U: 71%	U: 43%	U: 43%	U: 86%	U: 71%	U:86%	D: 43%	U: 57%
Boundary	National boundary	E: 86%	E: 100%	E: 100%	E: 86%	E: 43%	E: 71%	E: 57%	E: 100%	E: 71%
	First level internal boundary	E: 57%	E: 86%	D:57%	E: 43%	D: 43%	D: 43%	U:43%	D: 57%	D: 43%
	Second level internal boundary		E: 86%	D: 43%	Q: 71%	Q,U: 43%	Q,U: 43%	U:57%	Q: 57%	U: 43%
	coastline	E: 100%	E: 100%	E: 86%	E: 100%	E: 100%	E: 100%	E: 86%	E: 100%	E: 100%
	National or regional park	D: 43%		Q,U: 43%		U: 43%	E,D: 43%	U: 57%	D: 43%	E,D: 43%
Land cover	wood / forest	E: 71%	U: 43%	U: 57%	E: 86%	Q: 43%	E: 100%	U: 43%	E,Q: 43%	E: 57%
	Plantation or cultivated area	E: 43%	U: 57%	U: 57%	E: 86%	Q,U:43%	E: 100%	U: 57%	Q: 57%	
	Extensive non vegetated area	E: 57%	U: 57%	U: 57%	E: 86%	Q,U:43%	E: 100%	U: 57%	Q: 57%	

Other features	Major historic/ cultural site	D: 71%	U: 71%	U: 57%	U: 43%	U: 86%	U: 57%	U: 100%	E: 57%	Q: 57%
	landmark	D:57%	U: 71%	U: 57%	U: 43%	U:71%	U: 57%	U: 100%	E: 57%	Q: 57%
Topographic Features	Key spot heights	E: 71%	U: 86%	U: 71%	Q,U: 43%	E: 86%		Q,U: 43%	Q: 43%	D: 57%
	General relief information	E: 71%	U: 86%	U: 57%	E: 43%	E: 86%	D: 57%	D: 57%	D: 43%	E,D: 43%
	Detail height information	E: 57%	U: 86%	U: 57%	U: 43%	E: 71%	U: 43%	Q,U: 43%	D: 43%	E: 43%
transport	vehicular ferry	E: 57%	U: 43%	Q,U: 43%	Q: 43%	U: 71%	Q,U: 43%	U: 86%	E: 86%	Q: 57%
	passenger ferry	E: 57%	U: 43%	Q,U: 43%	Q: 43%	U: 71%	Q,U: 43%	U: 86%	E: 86%	Q: 57%
	Main line railway	E: 71%	D: 57%	U: 43%		U: 57%	D: 43%	U: 57%	E: 86%	D:57%
	Other railway	E: 43%	U: 57%	Q,U: 43%	U: 43%	U: 71%	U: 43%	U: 86%	E: 57%	U: 57%
	Airport	E: 43%	U: 43%	U: 43%		Q,U:43%		U: 43%	E: 57%	

4.4.3 Comparing the knowledge bases

By comparing the result of the survey of existing maps with the questionnaire results a few differences have been found. For major roads in land cover maps, in existing maps the score was 0% while in the experts view there is significant variation: E: 29%, D: 14%, Q: 29%, U: 29%. 57% of political maps reviewed have an isolated group of buildings, while 71% of experts said it is an unnecessary feature in this type of map. Furthermore, first level international boundary has been included in 9% of existing maps but 43% of experts think it is an essential feature in land use maps. 86% of experts think spot heights are an essential feature of relief maps, but only 13% of existing maps include this feature.

This comparison gives an insight into the difference between published mapping and the experts' view which they use in designing their maps. Without further investigation it is difficult to account for some of the significant differences. One explanation may be that many of the maps studied used a standard base map, which may not be particularly suitable for the topic, whereas the experts that had no constraints and chose their 'ideal' content. Table 4.8 gives an overview of the differences between existing maps and experts view.

Table 4.8 comparison of features included in existing maps and questionnaire: communication maps

features	questionnaire	existing maps
coastline	E:100%	89%
main river	E:86%	97%
lake	E:100%	94%
international boundary	E:100%	72%
county boundary	E:14%,D:57%	58%
capital, city	E:100%	100%
large town	E:71%	89%
motorway	E:100%	92%
primary route	E:100%	47%
railway	E:86%	44%
main relief	E:29%,D:43%	31%
minor relief	E:0%,D:43%	8%

In order to illustrate the differences between the two data collection methods a series of maps have been produced at the base scale of 1:250,000 Based on tables 4.5 and 4.7 all features that have a percentage of 40% or above have been chosen as features to be included in the map. For each map topic two maps have been produced with different contents. For example, according to the questionnaire results communication maps should include more feature classes than existing maps indicate. These features include railways, woodland, general relief, canal, and so on. These features may not be essential for this type of maps which is why they have not been found in the existing maps, but according to the experts' experience these features should be in this type of map. Maps A1, and A2 show the different between these views. For more examples, maps B1, B2, C1, C2 and D1, D2 show the differences between these two knowledge bases for topographic, population, and land cover maps.

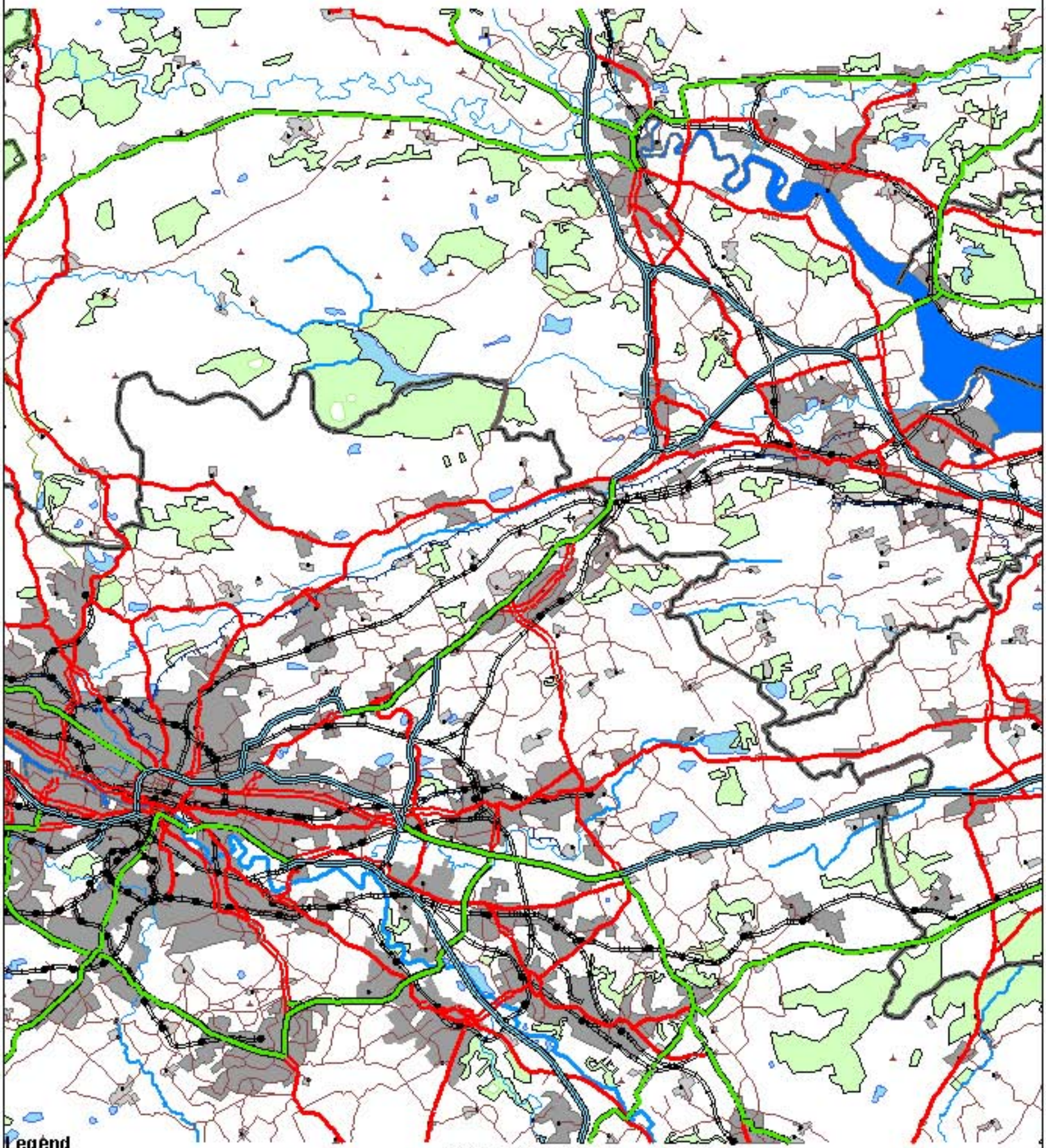
communication map (existing maps)

Legend

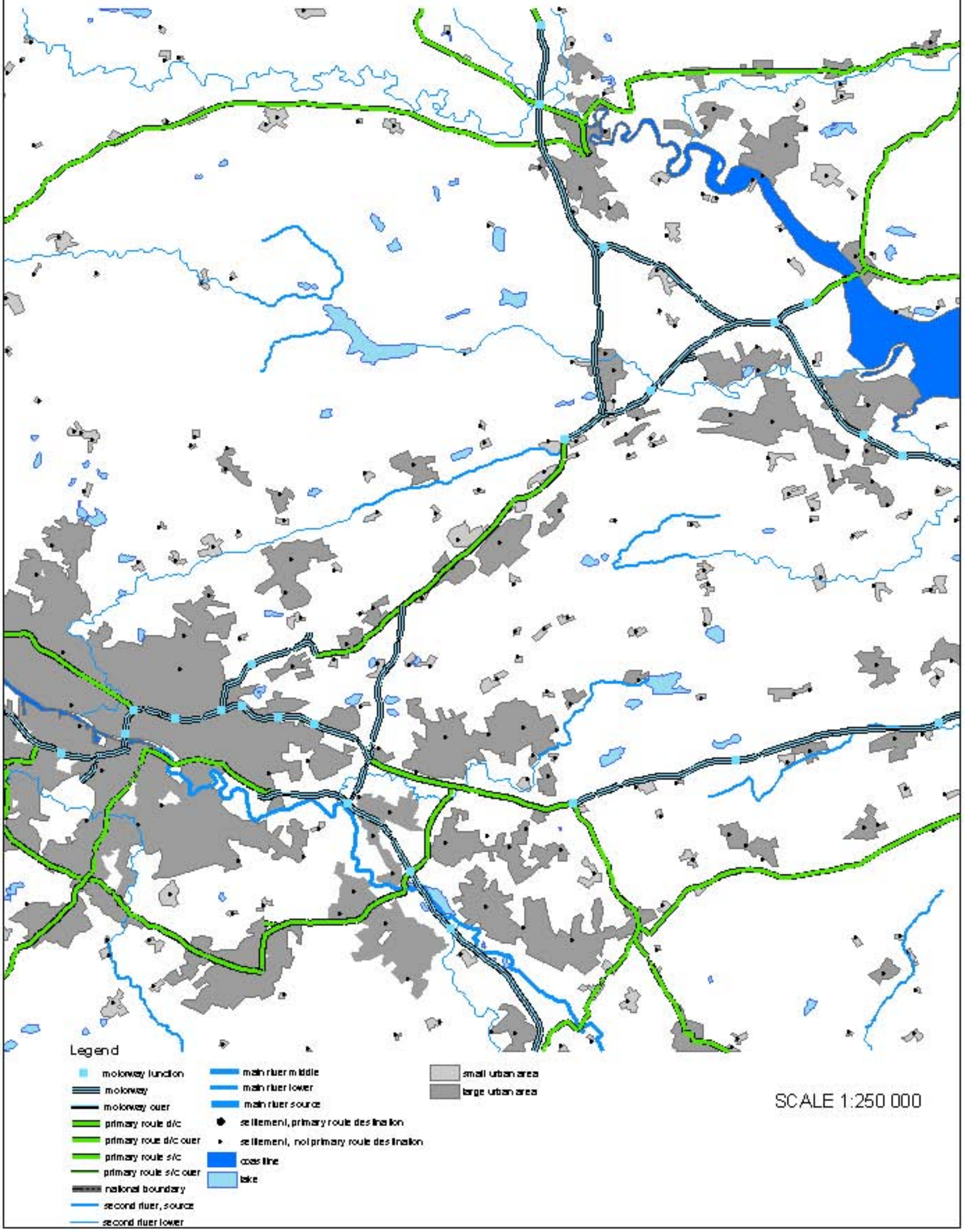
SCALE 1:250 000

- motorway
- motorway over
- primary route d/c
- primary roue d/c over
- primary route s/c
- primary route s/c over
- Aroad d/c
- Aroad d/c over
- Aroad s/c
- Aroad s/c over
- Broad d/c
- Broad d/c over
- Broad s/c
- Broad s/c over
- railway standard
- railway standard over
- minor/ other road
- minor/ other road over
- county boundary
- national boundary
- second river, source
- second river lower
- main river middle
- main river lower
- main river source
- settlement, primary route destination
- settlement, not primary route destination
- civil aerodrome no customs facilities
- civil aerodrome customs facilities
- feery vehicular
- coastline
- lake
- small urban area
- large urban area

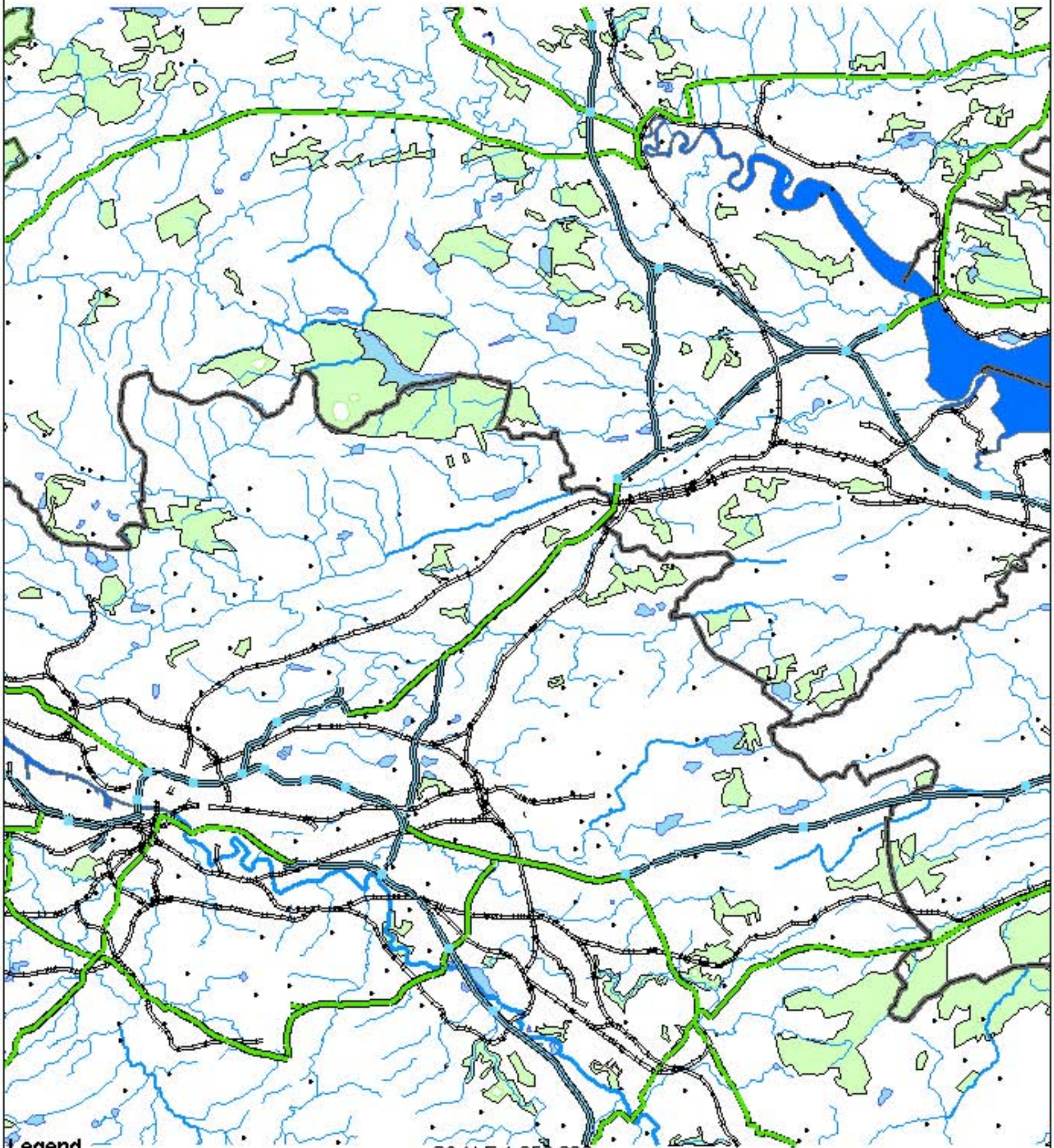
communication map (questionnaire)



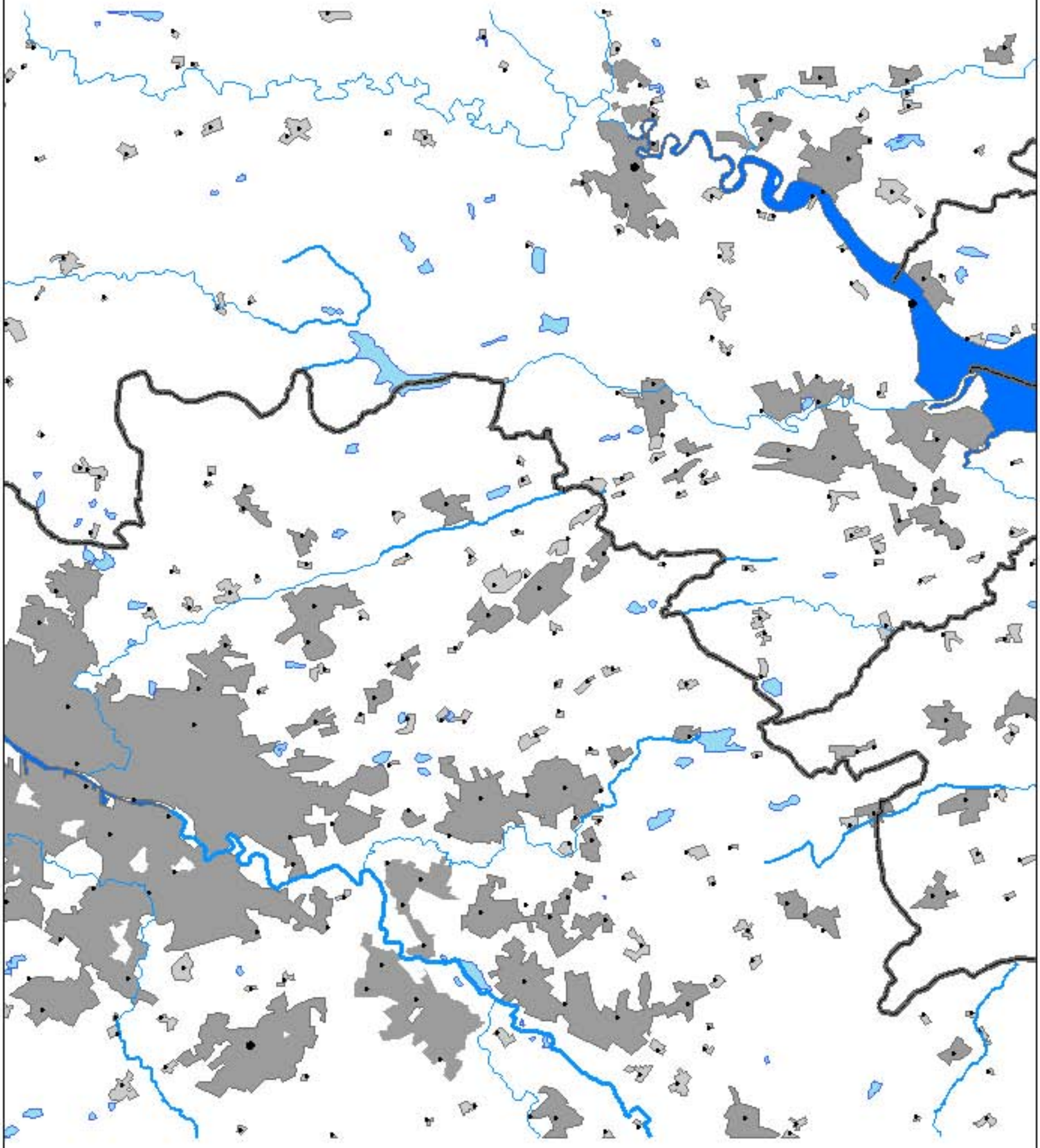
land cover map (existing maps)



land cover map (questionnaire)



population map (existing maps)

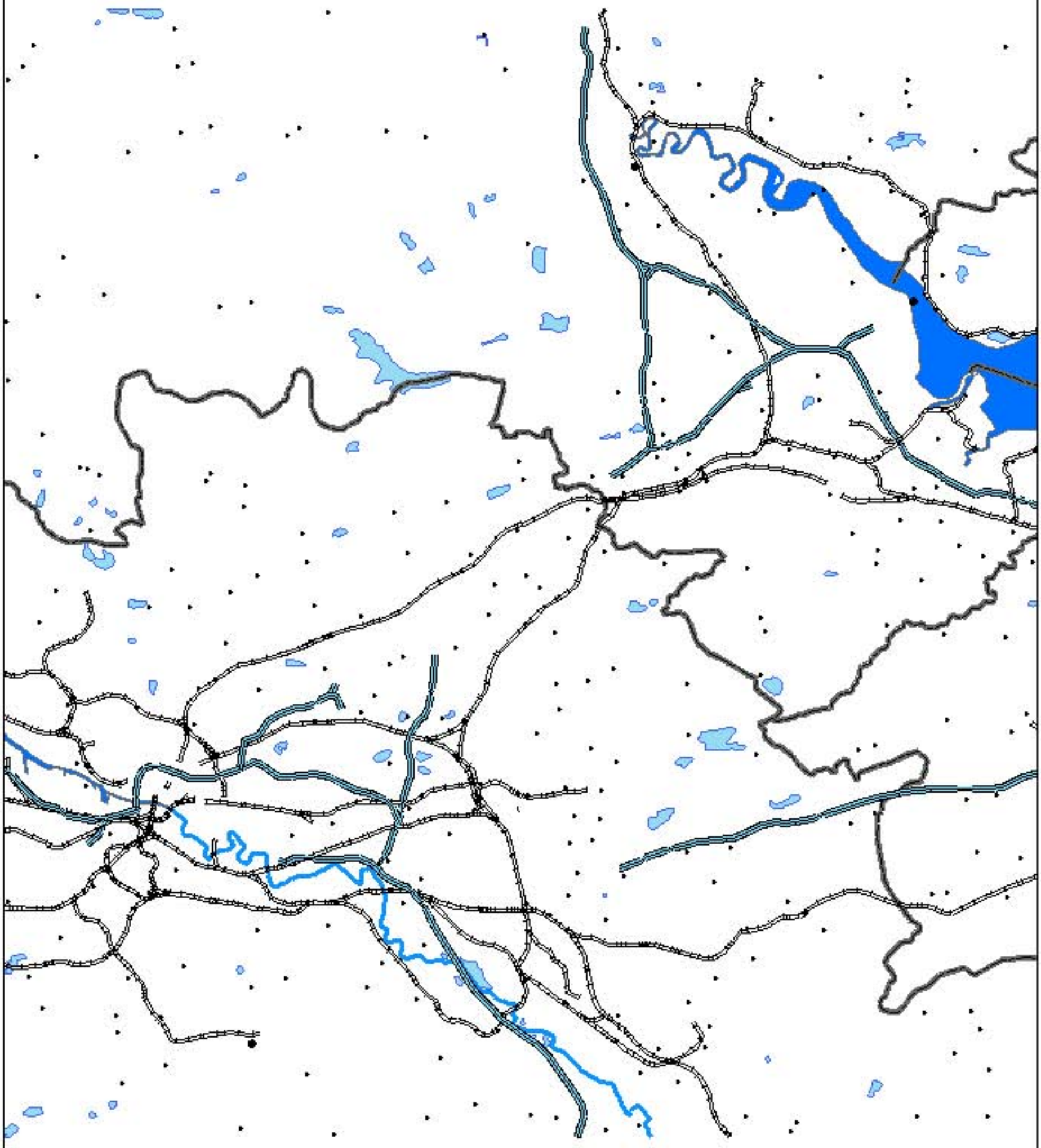


SCALE 1:250 000

Legend

- county boundary
- national boundary
- second river, source
- second river lower
- main river middle
- main river lower
- main river source
- settlement, primary route destination
- settlement, not primary route destination
- coastline
- lake
- small urban area
- large urban area

population map (questionnaire)



Legend

SCALE 1:250 000

- motorway
- motorway over
- railway standard
- railway standard over
- county boundary
- national boundary
- main river middle
- main river lower
- main river source
- settlement, primary route destination
- settlement, not primary route destination
- coastline
- lake

topographic map (existing maps)

Legend

SCALE 1:250 000

- motorwayjunction
- motorway
- motorway over
- primary route d/c
- primary roue d/c over
- primary route s/c
- primary route s/c over
- Aroad d/c
- Aroad d/c over
- Aroad s/c
- Aroad s/c over
- Broad d/c
- Broad d/c over
- Broad s/c
- Broad s/c over
- railway standard
- railway standard over
- railway narrow
- rialway narrow over
- minor/ other road
- minor/ other road over
- county boundary
- national boundary
- second river, source
- second river lower
- main river middle
- main river lower
- main river source
- settlement, primaryroute destination
- settlement, not primary route destination
- civil aerodrome no customs facilities
- civil aerodrome customs facilities
- coastline
- lake
- small urban area
- large urban area
- geographical area seed
- long distance footpath

topographic map (questionnaire)

Legend

SCALE 1:250 000

- motorway
- motorway over
- primary route d/c
- primary roue d/c over
- primary route s/c
- primary route s/c over
- Aroad d/c
- Aroad d/c over
- Aroad s/c
- Aroad s/c over
- Broad d/c
- Broad d/c over
- Broad s/c
- Broad s/c over
- railway standard
- railway standard over
- railway narrow
- rialway narrow over
- minor/ other road
- minor/ other road over
- county boundary
- national boundary
- second river, source
- second river lower
- main river middle
- main river lower
- main river source
- minor river
- canal
- canal over
- settlement, primary route destination
- settlement, not primary route destination
- civil aerodrome no customs facilities
- civil aerodrome customs facilities
- feery vehicular
- woodland
- coastline
- lake
- small urban area
- large urban area
- geographical area seed
- long distance footpath

4.5 Conclusion

In this chapter the features included in the topographic database have been discussed and organized into an hierarchical structure appropriate for automated selection.

Two different ways to collect and build a knowledge base have been discussed. This gives a clear idea about map content related to scale and topic. This knowledge will help in selecting appropriate map contents.

Comparing questionnaire responses and data collected from existing maps, there are clear differences in what experts think in theory should be included and actual practice. The knowledge from the experts is used to resolve some of the anomalies apparent in the initial knowledge base developed from the analysis of existing maps. Also, there is a weakness in the classification of features in the Ordnance Survey Strategi data. Work should be done to reclassify the features in order to make it easier to select the features to include in a range of maps.

The automated selection of map contents using this knowledge base needs be tested to assess the suitability of this knowledge base. This will be the main focus of the next chapter.

Chapter 5
Using the knowledge base

5.1 Introduction

Using computer programs such as GIS for designing maps makes selecting features or layers easy. But the data selected should be relevant to the topic of the map, map scale, level of detail required and the knowledge of the map user. All these factors will have an affect on the data selected.

In this study ArcGIS is used to produce example maps. Like many GIS, ArcGIS has a drop down list of database layers and feature classes that facilitates selecting data for inclusion in the map. However, there is no help from the system in choosing appropriate layers and feature classes and if the total number is extensive then the user needs to take some time in switching on (or off) the appropriate layers and features. It will be easy to miss something that may be important to the map being produced. Thus the next stage in this project after collecting data about map content will be developing procedures for automatically selecting features suitable for a given map scale and map topic. In this chapter the main focus is on selecting these features by using two different methods, then applying these selections in ArcGIS to produce maps at different levels of detail and different scales for different map topics to illustrate the outcome. If the experimental feature selection process proves successful, a future development would be automating this within the GIS environment.

The sample maps are all produced using Ordnance Survey Strategi data of an area around Glasgow. This data is derived from 1:250.000 scale maps and this scale is taken as the nominal scale of the database. The output scale will range from 1:250.000 to 1:1000.000 scale. This scale range reflects the principle that data should not be enlarged from its source scale (although in practice there is evidence that this frequently occurs) and the 4 times reduction in scale reflects a practical scale range where geometrical aspects of generalisation, such as line simplification, are not essential in most cases.

5.2 Selecting features from the database

Choosing the features that will be included in the map and that will help in producing the best map for certain topics and scales is the main aim of this study. Having created the knowledge base about potential content, the next step is to calculate a selection index for each map. The selection index will be calculated by using some key data about the required map in a formula. Two formulas have been tested in this study.

5.2.1 The first method:

The first method investigated is that previously used by Forrest (2003). As part of a map design expert system, Forrest automated the selection of topographic base information for thematic maps at scales from 1:2 million to 1:15 million scales. In order to do this a 'selection index' was calculated and compared to a matrix of desirability of including various classes of feature in maps with different topics.

In order to calculate the selection index, the level of detail required on a scale of 1-10 and the map scale had previously been determined based on user requirements. This was used to calculate the selection index using the formula below:

$$SI = 11 - \text{trunc}((Sc / Sm * 10 + LD) / 2)$$

where:

SI: selection index value from 1 to 10.

Sc: scale of source data.

Sm: scale of map output.

LD: required level of detail of output map from 1 to 10.

For each map topic, every topographic feature class in the database was given an inclusion score or selection score of between 0 and 10. An inclusion score of ten would mean the feature class should always be included in a map of that topic, and a score of zero would mean the feature

would never be included in the map. All features which have a score higher than or equal to the selection index (SI) value will be accepted for inclusion in a particular map, and the other features will be ignored.

The selection of topographic base information, while a key step, was only a small part of the development of the map design expert system. The scores for inclusion in the array of map topics were based on introspection by Forrest and examination of a single educational atlas as a model. The formula for the selection index was developed empirically. One outcome of this method is that as scale or level of detail is reduced, fewer feature classes are included, which is what is to be expected. Forrest (1996) noted that further investigation was required to confirm that appropriate scores were used for all features across the range of map topics and alternative methods of determining the selection could be considered.

Applying the Forrest Selection Index approach to the current study, each class of feature has been scored depending upon its relevance to each map topic based on the analysis of map content discussed in Chapter 4. This data will be grouped into six classes, each with its own score in the range 0 to 10. Thus there will be in effect being a matrix of such inclusion scores for each feature class for each feature map topic, as shown in Table 5.1.

Table 5.1 Scores for feature selection

Requirement for feature class	**Score**
Never required	0
Rarely required	2
Occasionally required	4
Often required	6
Usually required	8
Always required	10

In order to determine what features should be included in any specific map a selection index value is calculated. By using Forrest's formula, the

output map scale should be equal to or smaller than the source data scale. Also, calculating the selection index is strongly influenced by the required level of detail. For experimental purposes maps with three different levels of detail will be considered:

Detailed maps: LD = 10
Medium detailed maps: LD = 5
Simple maps: LD = 1.

The formula developed by Forrest gives a selection index in the range 1 to 10, the larger the final map scale or the higher the level of detail, the lower value of the selection index. Table 5.2 shows the selection index resulting from changes in the required level of detailed and by changing the map scale.

Table (5.2) Scale, level of detail and Selection Index value

	SC: 1:250 000		
SM / LD	1:250.000	1:500.000	1:1000.000
LD: 1	6	8	10
LD: 5	4	6	8
LD: 10	1	4	5

Map topic has a great effect on the map contents, thus the selection index score of the map features will change by changing the map topic. Table 4.10 in chapter 4 shows how the inclusion score for each feature class could be change from one topic to another.

In the current study, each topographic base feature has its own score for each map topic, depending upon the likelihood of it appearing on that type of map. This was determined by counting how many times each feature appeared on the maps studied and calculating a percentage (see chapter 4). This percentage gives an indication of the importance of each feature. This percentage were used to assist in determining a feature score in the range 0

to 10 for each map topic. For example: if the feature has been found in 30 maps and the total collected map is 50, then the percentage will be 60%, and the inclusion score is 6. But if the percentage is 26% the inclusion score in this case will be 4.

Having determined the selection index value, this is then compared with the knowledge base of feature scores for the appropriate topic. All features with a score equal to or greater than the selection index will be included in the map.

The set of features selected will thus be different from one map to another depending on the map topic, map scale, and the required level of detail. Table 5.3 shows the changes in content for a variety of topics, scales and level of details.

Table 5.3 Map content selected for a variety of map topics with different scales and level of detail.

examples of automatically selected base map features

	1	2	3	4	5	6	7	8	9
map topic	climate	population	land use	communication	relief	topographic	land cover	political	environmental
output scale Sm	250000	250000	250000	250000	500000	500000	500000	1000000	1000000
level of detail LD	1	10	5	1	5	10	1	10	10
Hydrographic features	lake	lake	lake	lake	lake	stream and wadi	lake	lake	lake
		rock	river/ main	canal	river/ main	lake	main river	river/ main	river/ main
		river/ main	2nd river	vehicular ferry	2nd river	cliff- slope	2nd river		2nd river
		2nd river		river/ main		sand dunes			
		marsh- swamp		2nd river		canal			
						passenger ferry			
						river/ main			
						2nd river			
						marsh- swamp			
						vehicular ferry			
boundaries	state boundary	national boundary	national boundary	national boundary	coastline		coastline	national boundary	national boundary
	coastline	county boundary	coastline	county boundary				county boundary	coastline
		state boundary		coastline				state boundary	
		coastline						district boundary	
								coastline	
settlements cultural	city	city	city	city	city	city	city	city	city
	town	town	town	town	town	town		town	town
		2nd town	urban area	2nd town	urban area	2nd town		2nd town	
		other town		village		other town		village	
		village		urban area		village		urban area	
		small village				small village			
		urban area				urban area			
communication (transport)		motorway	motorway	full + limmited access		motorway		motorway	
		primary route	motorway junction	motorway junction		motorway junction		motorway junction	

			primary route	primary route		primary route		primary route	
				main road		main road		standard railway	
				secondary roads		secondary roads			
				other road		other road			
				gradients- sleep		all weather road			
				toll		footpath, trail			
				standard railway		standard railway			
				airport		narrow			
						railway tunnel			
						single standard			
						single narrow			
						multiple standard			
						multiple narrow			
						railway station			
						airport			
						airfield			
						seaplane port			
elevation		point(spot heigh)		height		point(spot heigh)			
						distance			
						contour			
						height			
tourist						cathedral			
land use		wood forest	wood forest			wood forest			
			orchard			ruin			
						lighthouse			

One of the aims of this study is to test the formula developed by Forrest. This formula was developed for maps at scales from 1: 2 million to 1:15 million. Thus comparing the results calculated using selection index with the map content survey will help in making a decision if this formula is working for the scales used here or not.

According to Forrest's formula by reducing the scale or the level of detail fewer feature classes will be selected. Changing the map scale from 1:250.000 to 1:1000.000 less detail should be included in the map. Also, maps with higher level of details will include more feature classes than maps with a lower level of detail. For example, for topographic maps table 5.4 and with 1:250.000 as a base scale, by moving from LD: 10 to LD: 1 or reducing the scale some features have been removed, such as second class river, country boundary, second class town and so on.

Table 5.4 The change of topographic maps' content for different level of detail and different output scales (SI = feature's inclusion score. From 1 to 10).

topographic maps

	Output Scale		250000			500000			1000000		
	Level of Detail		LD:16	LD:54	LD:101	LD:18	LD:56	LD:104	LD:110	LD:58	LD:105
FEATURES	sub features	SI									
motorways	normal	10	*	*	*	*	*	*	*	*	*
	under construction	2			*						
	motorway tunnel	0									
	full + limited access	2			*						
	motorway junction	4		*	*			*			
primary route	primary route	6	*	*	*		*	*			*
	dual carriageway	2			*						
	under construction	2			*						
	single carriageway	0									
	tunnel	0									
a roads	main road	6	*	*	*		*	*			*
	dual carriageway	2			*						
	under construction	2			*						
	single carriageway	2			*						
	narrow roads	0									
b roads	secondary roads	6	*	*	*		*	*			*
	dual carriageway	2			*						
	narrow road	2			*						
minor road	minor road	2			*						
	under construction road	0									

	other road	6	*	*	*		*	*			*
	unclassified road	0									
additional road features	projected by pass roads	2			*						
	all weather road	4		*	*			*			
	dry weather road	2			*						
	narrow road with passing places	2			*						
	gradients- sleep	2			*						
	toll	2			*						
	footpath, trail	6	*	*	*		*	*			*
	cart track	2			*						
	loose surface	2			*						
	cross road	2			*						
	national road	0									
railway	standard	6	*	*	*		*	*			*
	narrow	4		*	*			*			
	railway tunnel	4		*	*			*			
	single standard	4		*	*			*			
	single narrow	4		*	*			*			
	double standard	2			*						
	double narrow	2			*						
	multiple standard	4		*	*			*			
	multiple narrow	4		*	*			*			
	railway station	4		*	*			*			
	tourist railway	2			*						
water feature	stream and wadi	4		*	*			*			
	lake	10	*	*	*	*	*	*	*	*	*
	dam	2			*						
	glacier	2			*						
	glacial moraine	2			*						
	spring- well- cistern	2			*						
	cliff-slope	4		*	*			*			
	foreshore area	2			*						
	sand dunes	4		*	*			*			
	rock	2			*						
	mudflat	2			*						
	bridge	2			*						
	tunnel	0									
	canal	4		*	*			*			
	navigable canal	2			*						
	non navigable canal	2			*						
	vehicular ferry	4		*	*			*			
	ferry route link	0									
	passenger ferry	4		*	*			*			
	river/ main	8	*	*	*	*	*	*		*	*
	2nd river	6	*	*	*		*	*			*
	marsh- swamp	6	*	*	*		*	*			*
settlements	city	8	*	*	*	*	*	*		*	*
	town	8	*	*	*	*	*	*		*	*

	2nd town	6	*	*	*		*	*			*
	other town	6	*	*	*		*	*			*
	village	6	*	*	*		*	*			*
	small villages	4		*	*			*			
	landmark feature	2			*						
	urban area	6	*	*	*		*	*			*
boundary	national boundary	10	*	*	*	*	*	*	*	*	*
	county boundary	6	*	*	*		*	*			*
	state boundary	8	*	*	*	*	*	*		*	*
	district boundary	2			*						
	sub district boundary	0									
	national forest park	2			*						
	coastline	10	*	*	*	*	*	*	*	*	*
	national park	4		*	*			*			
land use	wood forest	4		*	*			*			
	orchard	2			*						
	mine	4		*	*			*			
	airport	6	*	*	*		*	*			*
	airfield	4		*	*			*			
	seaplane port	4		*	*			*			
	heliport	2			*						
	ruin	4		*	*			*			
	lighthouse	4		*	*			*			
	lightship	2			*						
	mound	2			*						
	zone	2			*						
tourist features	castle	2			*						
	historic house	2			*						
	park- garden	2			*						
	cathedral	4		*	*			*			
	battle site	2			*						
	nature reserve	2			*						
	wildlife park	2			*						
	information centre	2			*						
	golf course	2			*						
	youth hostel	2			*						
	motor racing centre	2			*						
	race course	2			*						
	camping- caravanning	2			*						
	cave	0									
	museum- theatre	2			*						
	nature or forest trail	0									
	skiing	2			*						
	railway	0									
	zoo	0									
	other tourist feature	2			*						
	antiquities	2			*						
topographic features	horizontal control	2			*						
	point(spot heigh)	6	*	*	*		*	*			*
	distance	4		*	*			*			

	submarine contours	2			*						
	contours	10	*	*	*	*	*	*	*	*	*
	mileage	0									
	height	4		*	*			*			
populated places		2			*						

By comparing the selection index score with the questionnaire and the existing maps results, the features removed do not have a 100% score. This is because they are not essential features for all levels of detail and for different scales. Some examples are given in Table 5.5 and the full details of the selection results for all features for different map topics and different scales can be found in appendix D and E. For example, 2nd class river has 71% as an essential feature in the questionnaire and 59% in the existing maps. This feature has been removed from the maps at output scale 1:500.000 for LD: 1, and in maps at 1:1000 000 and LD: 1&5. After comparing all the results with the selection features, Forrest's formula seems to work for the tested scales of 1:250.000, 1:500.000 and 1:1000.000.

Table (5.5) Comparison of data selected using SI scores with data collected from existing maps and questionnaire for different map topics.

				Scale	1:250000			1:500000			1:1000000		
				Level of detail	LD:1	LD:5	LD:10	LD:1	LD:5	LD:10	LD:1	LD:5	LD:10
				Selection index	6	4	1	8	6	4	10	8	5
Map topic	**Feature**	**inclusion score**	**questionnaire**	**existing maps**									
Communication maps	state boundary	8	E,D,Q:29%	26%	*	*	*	*	*	*		*	*
Land use maps	international boundary	10	E:86%	36%	*	*	*	*	*	*	*	*	*
	state boundary	6	E:14%	18%	*	*	*		*	*			*
	county boundary	2	E:43%	9%			*						
Climate maps	main river	10	E:43%	25%	*	*	*	*	*	*	*	*	*
	2nd class river	8	E:14%	25%	*	*	*	*	*	*		*	*
	urban area	4	E:0%	50%		*	*			*			
Environmental maps	large town	6	E:29%,D:57%	73%	*	*	*		*	*			*
	urban area	4	E:14%	46%		*	*			*			
	minor relief	2	E:43%	5%			*						
Topographic maps	coastline	10	E:100%	38%	*	*	*	*	*	*	*	*	*
	state boundary	8	E,D,Q:29%	26%	*	*	*	*	*	*		*	*
	large town	8	E:57%	85%	*	*	*	*	*	*		*	*
Political maps	coastline	10	E:100%	64%	*	*	*	*	*	*	*	*	*
	main relief	4	E:0%	21%		*	*			*			
Population maps	lake	8	E:43%	78%	*	*	*	*	*	*		*	*
	main river	10	E:29%,D:57%	100%	*	*	*	*	*	*	*	*	*

5.2.2 The second method:

For comparison, another feature selection method proposed by Richardson and Muller (1991) was also tested. In their study, data was selected from Canadian base maps at very small scales: 1:2 m, 1:7.5 m, 1:12.5 m, and 1:30 m. These data have a background information for 44 different map topics, including physical, human, economic, and historical theme. Selection data were applied to 14 different classes of objects that support thematic mapping. These classes are city, town, village, unincorporated place, non- incorporated place, Indian reserve, military reserve, rivers, lakes, islands, international boundary, provincial boundary, census division boundary and glaciers.

Richardson divided her work into two types of evaluation for each class of feature. The first type is based on the requirement of a base map object for 4 different scales and 44 objects. Two types of survey were done to establishing the requirements. The first survey was an interview with the staff at the Canada Centre for Mapping to determine the desirability of base map objects. The second survey was reviewing the presence or absence of base map objects on 110 existing maps to provide an objective means of assessing requirements. All the result were rated into 4 groups each with its own percentage: Essential: 100%, desirable: 75%, questionable: 25%, and unnecessary features: 0%. In the first group, the object is needed to link or support thematic component (e.g. river network). In the second group, the feature is not essential but helps to give orientation or description to thematic components (e.g. glaciers in zoogeography). For the third group, the feature could be used but would not be necessary (e.g: glaciers in a transport map). In the unnecessary group, feature is unusable or would be seen as illogical to use. (e.g. political boundary in phytogeography map).

The second type of evaluation was based on the functionality and used to determine why and for what purpose and object appears on a map at a given scale. Then 14 classes of base map features were rated according to 5 types of activities. Each type has a percentage: orientation: 80%, location:

90%, enumeration: 90%, measurement: 90%, and description: 100%. Requirement and functionality both will affect on the selection rules (selection index) by calculating a necessity factor (NF). All classes which have a high necessity factor should be selected and should be added to the map.

$(NF)_{IK} = ½ (R_{IK} + F_I)$

R_{IK}: the requirement rating for each base map object class.

I: classes of features that support thematic maps, 1-14

K: map topic, 1-44

F_I: 1/5 (Fn)

N: 1-5

According to Richardson's formula the necessity factor for mapping climatology at 1:7500 000 is represented in table 5.6.

Table (5.6) Calculation of the necessity factor for base map objects on climatology maps at 1: 7500.000 (after Richardson, 1991).

necessity factor for mapping climatology at 1:7.500.000			
object	requirements %	functionality %	necessity factor %
cities	100	87	93
towns	75	87	81
villages	25	54	39
unincorporated	0	21	10
non- unincorporated	0	0	0
Indian reserves	25	21	22
military	25	5	15
international boundary	100	90	100
provincial boundary	100	90	100
census division	0	50	0
rivers	100	74	87
lakes	100	54	77
islands	0	22	11
glaciers	25	21	23

For applying data to this formula all features will be described in four groups: E for essential, D for desirable, Q for questionable, or U for unnecessary. For these four groups all features will have a new score

Group	Score
E	10 100%
D	7 75%
Q	4 25%
U	1 0%

This study does not make a clear distinction between elimination and selection. As an example, rivers are used as a single class and there are no sub-classes. Also, city, town, and village are considered as main classes not as sub-classes of settlement features.

A necessity factor, which decreases with a decrease in scale, provides a general guideline for which features will be applied to a map and how many objects should appear on a map of a particular subject and scale. But it is not specific which objects within an object class must be selected. For solving this problem a set of rules were developed for each object class. These rules will help in determining which objects should be selected depending on the necessity factor. For example, rivers in the climatology map have a necessity factor for river is 83 %; this means that 17 % of rivers should be eliminated. Dropping streams with a low stream order could achieve this. The length at the specific source scale could be used to make the decision when more than one stream has the same order. But how the other classes could be eliminated, like a city or boundary, is not discussed.

5.3 Comparing the results

5.3.1 Comparison of Forrest and Richardson:

Forrest worked with thematic maps at scales from 1:2 million to 1:15 million and tried to automate the selection of topographic base information. Thus a selection index was calculated and compared with a matrix of selection scores (inclusion scores). The selection score dictates the features that will be included in a particular map. Relating to Forrest's work, table 5.7

shows the selection score for different map topics. In this table, some features like coastline and international boundaries always have a high score, ”10” for all types of maps, while some features have varied scores, like capitals, main town and main relief. These different scores show how the map contents should vary from topic one to another.

Table 5.7 Forrest's feature class inclusion scores for different map topics(after Forrest 2003)

Map topic	Topic class	Coastline	Major rivers	Large rivers	Other rivers	Large lakes	International bonaries	State boundaries	Tertiary boundaries	Capitals	Main towns	Minor towns	Urban areas	Main highways	Highways	Other roads	Railways	Main relief	Minor relief
Basic	Basic	10	0	0	0	8	10	0	0	0	0	0	0	0	0	0	0	0	0
Cultural	Cultural	10	6	3	0	8	10	8	6	10	9	8	6	9	7	5	6	2	0
Physical	Physical	10	10	9	7	10	10	6	1	5	3	1	2	4	2	0	2	8	5
Outline	Basic	10	6	3	0	8	10	6	1	5	3	2	2	4	2	0	2	2	0
Topographic	Basic	10	10	8	6	10	10	8	6	10	8	6	6	10	8	4	8	10	6
Political	Cultural	10	6	3	0	9	10	9	6	10	9	8	6	8	7	5	6	2	0
Population	Cultural	10	6	3	0	8	10	9	7	10	9	8	6	9	7	5	6	2	0
Economic	Cultural	10	6	3	0	8	10	8	6	10	9	8	6	9	7	5	6	2	0
Settlements	Cultural	10	6	3	0	8	10	9	6	10	10	9	8	10	7	5	8	4	0
Urban population	Population	10	6	3	0	8	10	9	6	5	2	1	3	9	7	5	6	2	0
Rural population	Population	10	6	3	0	8	10	9	8	10	9	8	6	9	7	5	6	2	0
Industries	Economic	10	6	3	0	8	10	8	6	10	9	8	6	9	7	5	6	2	0
Agriculture	Economic	10	10	9	7	10	10	6	1	5	3	1	2	4	2	0	2	8	5
Communications	Economic	10	6	3	0	10	10	8	6	10	9	8	6	9	7	5	6	2	0
Relief	Physical	10	10	9	7	10	10	6	1	5	3	1	2	4	2	0	2	10	8
Land cover	Physical	10	10	9	7	10	10	6	1	5	3	1	2	4	2	0	2	8	5
Climate	Physical	10	10	9	7	10	10	6	1	5	3	1	2	4	2	0	2	8	5
Soils	Physical	10	10	9	7	10	10	6	1	5	3	1	2	4	2	0	2	8	5
Vegetation	Land cover	10	10	9	7	10	10	6	1	5	3	1	2	4	2	0	3	8	5
Geology	Land cover	10	10	9	7	10	10	6	1	5	3	1	2	4	2	0	2	8	5
Precipitation	Climate	10	10	9	7	10	10	6	1	5	3	1	2	4	2	0	2	8	5
Temperature	Climate	10	10	9	7	10	10	6	1	5	3	1	2	4	2	0	2	8	5

Richardson's work studied the selection of content for thematic maps and at scales from 1:2 million to 1:30 million. Certain feature classes for different topics have different evaluations. For example for maps at scale 1:2million, river is an essential class for all map topics, but for different types of map, city could be an essential or desirable feature.

Table 5.8 Richardson's results for maps at scale 1:2 000.000 and for different topics (after Rechardson1991)

Subject Realm Requirement for Base Map Objects at 1:2,000,000										
Base Map Object	Geophysics	Geology	Geomorphology	Climatology	Hydrology	Pedology	Phytogeography	Zoogeography	Ecology	Environment
City	●	○	●	●	○	○	○	○	○	●
Town	*	*	●	●	○	○	*	○	○	●
Village	–	–	○	○	–	*	*	○	○	○
Unincorporated	–	–	*	*	–	*	*	*	–	○
Non-unincorporated	–	–	–	–	–	–	–	–	–	–
Indian Reserve	–	–	*	○	○	○	*	*	○	○
Military	–	–	*	○	○	*	–	–	*	*
Rivers	●	●	●	●	●	●	●	●	●	●
Lakes	●	●	●	●	●	●	●	●	●	●
Islands	–	–	–	–	●	○	○	*	*	*
International	●	●	●	●	●	●	●	●	●	●
Provincial	●	●	●	●	●	●	●	●	●	●
Census Division	–	–	–	–	–	–	–	–	*	*
Glaciers	*	○	●	○	●	○	●	○	●	●

● Essential ○ Desirable * Questionable – Unnecessary

Comparing the results of Forrest and Richardson's studies for the same base map scale of 1:2 million and for the same topics the results are not always the same. For example, according to Richardson rivers, lakes, and international boundaries are always essential classes. In Forrest's work classes that always have a high selection score are coastline and international boundaries, while lake and rivers have a high score for some types of map like agriculture, climate, and geology. Capital and large city in Forrest's study have a score varying from 0 to 10 while in Richardson's work they are always essential or desirable. Town in Richardson's study is an essential in climatology, questionable in geology and desirable in hydrology map. While in Forrest work, it has scores: 0,2,3,8,9, and 10 depending on the map topic.

5.3.2 Comparison of Forrest, Richardson, questionnaire and existing maps:

With the aim of finding if the formula used will work for the scales in the current study, the results have been compared with the results in Richardson's research for the maps at 1:2.000.000 scale which is the closest scale to the research scales.

According to this comparison, some features that are essential in Richardson do not have a high percentage in the questionnaire, or existing maps. Also, the same features were not selected in the maps at different required level of detail and for different output scales. For example in the environmental maps, main river which is an essential according to Richardson has 100% in the questionnaire and 91% in the existing maps. This feature has also been selected in Forrest's results. Capital or city, which is also an essential in Richardson's results, has e:71% in questionnaire and E:87% in existing maps, but has not been chosen in the maps produced for some levels of detail using Forrest's formula. Full details are shown in Table 5.9.

Table 5.9 comparison of data selected using SI scores with data collected from existing maps and questionnaire with Richardson's result for environmental maps

features	inclusion score ld	Richardson 1/2000 000	questionnaire	existing maps	Forrest (SI)								
					1:250000			1:500000			1:1000000		
					LD:16	LD:54	LD:101	LD:18	LD:56	LD:104	LD:110	LD:58	LD:105
main river	10	E:100%	E:100%	91%	*	*	*	*	*	*	*	*	*
lake	10	E:100%	E:100%	82%	*	*	*	*	*	*	*	*	*
international boundary	10	E:100%	E:71%	64%	*	*	*	*	*	*	*	*	*
capital, city	6	E:100%	E:71%	87%	*	*	*		*	*			*
large town	6	E:100%	E:29%,D:57%	73%	*	*	*		*	*			*

Comparing these two previous studies together with questionnaire and existing maps results will help in modifying Table 4.10 to remove any anomalies created due to the data capture methodology. Table 5.10 shows the final selection scores that will be used to choose feature classes when producing example maps.

Table (5.10) Modified selection (Inclusion) scores for various map topics

Features	sub features	Relief	Communication	political	topographic	land use	Population	Land cover	Environmental	Climate
motorways	normal	4	8	8	10	6	2	6	4	4
	motorway tunnel	0	4	0	0	0	0	0	0	0
	motorway junction	4	6	6	4	4	0	6	4	4
primary route	primary route	4	6	6	6	4	2	6	2	4
a roads	main road	2	8	2	6	2	0	0	2	2
b roads	secondary roads	2	8	2	6	2	0	0	2	2
	other road	2	6	4	6	0	0	2	2	2
railway	standard	2	6	6	6	2	0	2	4	2
	narrow	0	2	0	4	0	0	0	0	0
	railway tunnel	0	4	2	4	0	0	2	2	0
	railway station	0	4	2	4	0	0	0	2	0
	tourist railway	0	2	0	2	0	0	0	0	0
water feature	lake	10	10	10	10	10	10	10	10	10
	tunnel	2	0	0	0	0	0	0	0	0
	canal	4	6	2	4	2	0	0	4	0
	vehicular ferry	0	6	2	4	0	0	2	2	0
	ferry route link	0	2	0	0	0	0	0	0	0
	river/ main	10	10	6	8	8	10	8	10	10
	2nd river	8	6	4	6	6	8	8	6	8
settlements	city	8	10	10	10	10	10	8	6	8
	town	6	8	8	8	4	10	6	6	8
	2nd town	2	6	6	6	0	10	2	2	0
	other town	0	4	2	6	0	6	2	2	0
	village	4	6	6	6	0	10	2	2	2
	small villages	2	4	4	4	0	8	2	0	0
	urban area	6	6	6	6	8	6	6	4	4
boundary	national boundary	10	10	10	10	10	10	10	10	10
	county boundary	2	8	8	6	2	8	2	4	4
	state boundary	6	8	8	8	6	4	6	6	6
	national forest park	2	4	0	2	0	0	2	0	2
	coastline	10	10	10	10	10	10	10	10	10
	national park	0	4	2	4	2	0	2	0	0
land use	wood forest	0	4	2	4	6	2	4	2	0

	airport	2	8	8	6	2	0	2	2	0
topographic features	point(spot heigh)	8	4	2	6	0	2	4	4	4
	distance	2	4	0	4	0	0	0	0	0
	submarine contours	0	2	0	2	0	0	0	0	0
	contours	10	2	4	10	0	0	2	8	8
	height	6	6	2	4	0	0	2	4	4

5.4 Using ARCGIS in producing new maps

The final step in this study is using ARCGIS to produce example base maps; these base maps only include the topographic base information required and have no special topic information. After printing these maps, a big difference in content has been found between maps at the same scale and same topic, but with different level of required detail. It shows how maps with higher level of detail includes more base information than those with lower level of detail. For example, in producing land cover maps at 1:250 000, by moving from level of detail (LoD) 5 to LoD 1 woodland has been removed; also in the maps produced between LoD 10 and LoD 5 railways and roads are removed. By comparing maps produced for population, topographic, land cover, and communication at different output scales and different levels of required detail, several issues have been noted and are discussed below.

Land cover maps based on the 'existing maps' data and produced at 1:250.000 and level of detail 1 are similar to maps at output scale1:500.000 and LD: 5, while between maps based on the questionnaire results and 'existing maps' results there are big differences in content.

For population maps and between 'questionnaire' and 'existing maps', motorway and urban area have been missed. 'Existing map' results are similar to the selection at 1:250.000 and LoD:5. Also, maps at 1:250.000 and LoD:1, 1:500.000 and LoD:5, and maps at 1:1000.000 and LoD:5 are similar to each other.

For communication maps and between 'existing maps' and 'questionnaire map' a few features have been missing like woodland, railway

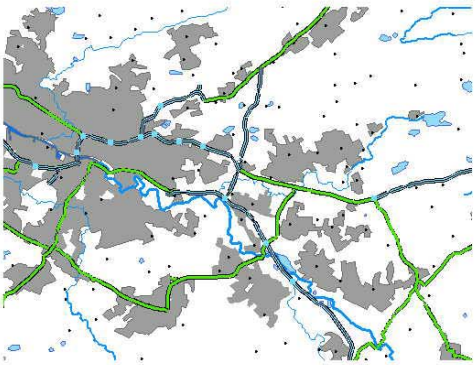
station, canal, and so on. The questionnaire map is similar to the map at 1:250.000 and LoD:10 and the map at 1:250.000 and LoD:5.

For topographic maps, ‘existing maps’ is similar to map at 1:250.000 and ld:1 while ‘questionnaire’ is close to map at 1:250.000 and ld:5 and map at 1:250.000 and ld:10.

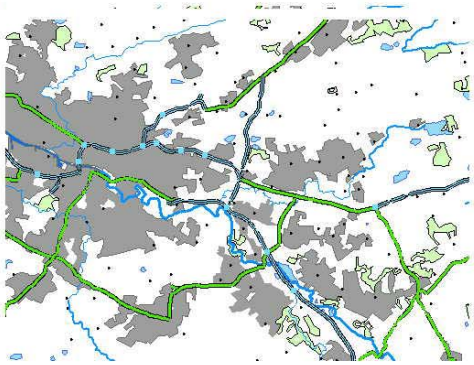
One thing that emerges from this comparison is that there does not seem to be any general rule that a map at scale S1 with level of detail D1 will have similar content to a map at scale S2 with level of detail D2.

The maps in Figures 5.1 and 5.2 are examples of those produced in this research. All the features that have been included in these base maps have been selected according to Forrest’s formula for the selection index. These map extracts have been printed at scale 1:250.000 at 3 levels of detail and at a medium level of detail at 3 scales to allow comparison. Comparing population and land cover maps at the same scale but different levels of detail and maps at the same level of detail but at different map scales, it is clear that there is a strong relationship between scale and level of detail.

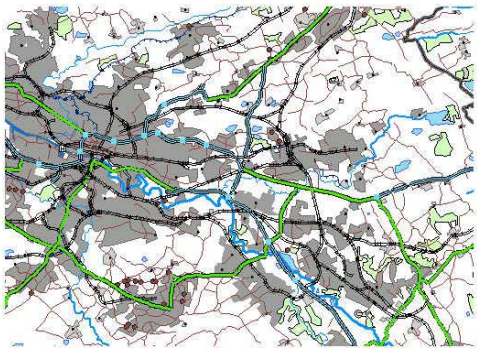
Figure 5.1 Land Cover Base Maps



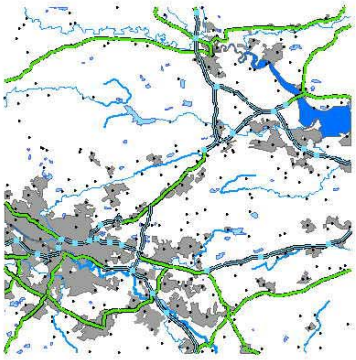
1:250.000, LD: 1



1:250.000, LD:5



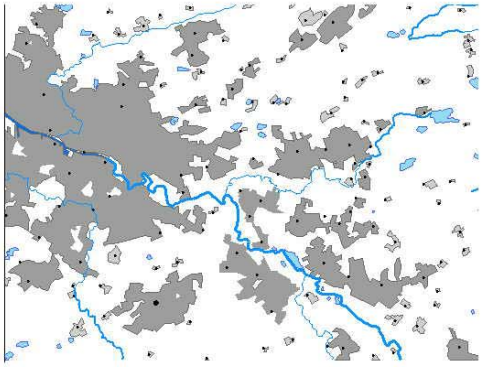
1:250.000, LD:10



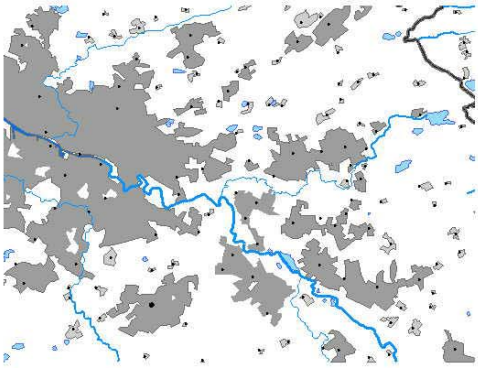
1:500.000, LD:5

1:1000.000, LD:5

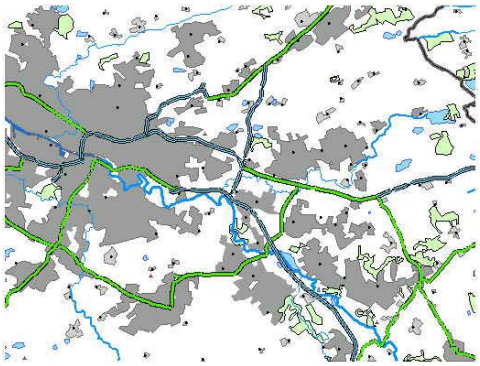
Figure 5.2 Population Base Maps



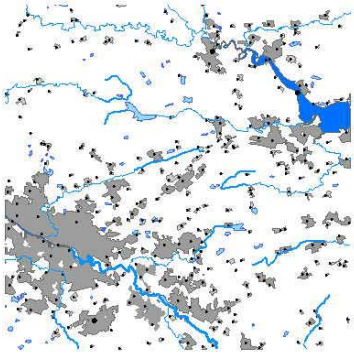
1:250.000, LD:1



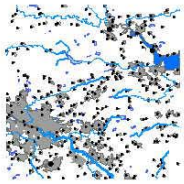
1:250.000, LD:5



1:250.000, LD:10



1:500.000, LD:5



1:1000.000, LD:5

All the maps produced have been collected in appendix H. All have been printed at 1:250 000 scale to allow easy comparison of content.

5.5 Conclusion

According to the comparisons in this study, a clear relationship between map scale, map topic and the required level of detail has been found, but this relationship is not consistent across all map topics. Also, the chosen formula does appear to be appropriate for choosing the contents of the required maps and the application of this method will make producing maps easier and faster. However the changes in content to not always match what might be expected from the study of existing maps or the questionnaire results, indicating some refinement of the knowledge base or selection procedure might be required.

Chapter 6
Conclusion

In the last few years automated mapping has become a major issue in cartographic research. Currently it requires a large degree of human interaction to produce an acceptable map. Computer programs make designing maps easier and faster, but the user of these programs may have no cartographic knowledge, thus the design of the map may not be good enough.

The main emphasis of this study concerned the selection of topographic base information for maps on a wide range of different topics, different map scales and various level of detail. For selecting these contents formulas have been used. The formulas used were created originally for certain small scales, but were tested for their applicability at larger map scales. Scales from 1:250 000 to 1:1000 000 are the chosen scales for testing these formula.

Making a decision about the content and graphic design of the map is strongly affected by the map purpose which should be clear, the map scale which is a filter for the information content of the map, the geographical area and the required level of detail also affect on the selected features.

For this study data has been collected from two different sources. First, maps at different scales and various topics were examined. The second source of data is a questionnaire that was sent to cartographers and map topic experts and covered the same map topics and scales. Comparing these results helped in developing a new procedure to select the map features depending on map scale and map topic.

To achieve the aims of the study data has been collected from 157 existing maps and 11 atlases. All the data was collected from maps at (or close to) scales of 1:250.000, 1:500.000 and 1:1000.000. To discover the

relation between map contents and the scale and map topic, the collected data has been divided into two groups. The first group includes maps with different scales and same topic. Comparing data in this group helps in finding the effect of changing scale on the data included. The second group includes maps of different topics but at the same scale to help in finding the relation between map topic and map content.

To test the outcomes Ordnance Survey Strategi digital data with a nominal scale of 1:250.000 has been used. A four level hierarchical classification of all the features is used to organize the data with the seven main layers being: hydrology layer, boundary layer, land use layer, relief layer, transportation layer, settlement layer and cultural layer.

One aim was to investigate the difference in map content between existing maps and the view of experts. According to this comparison, differences between expert's view and published map have been found, with the general outcome being that experts expected more base information to be included. This could be because the base information in the maps used in this research were not ideal for the topic they show. Also, the experts may not have a clear idea about the right contents of these maps without seeing it in front of them. That is, they may not be able to visualize the level of detail of the map from a list of possible content. It would be interesting to investigate if they modified their selection on seeing a draft map..

With the aim of automating the selection of contents, two formulas have been tested. One of these formulas was Richardson's formula. This formula does not give a clear view about the selected or eliminated features, and the necessity factor gives general guidelines for the selected features and how many features will be presented in the map for a particular scale and topic. For example, 70% of towns will be selected in map at x scale and y topic. Thus more rules will be involved to help in choosing the necessary features. As a result of this, it is not easy for the map maker to use this formula in producing a map.

The second used formula was Forrest's formula. While it was created for maps at scales from 1:2 million to 1:15 million, this formula has been tested for three scales: 1:250.000, 1:500.000 and 1:1000.000. A selection index was calculated and compared with an inclusion score in the knowledge base which is based on the collected data. This comparison helped in selected different classes of features for maps at different scales and topics.

Comparing the results of Forrest and Richardson's studies for the same base map scale and the same topics the results are not always the same. Features that have a high selection scores according to Forrest are not essential in Richardson. In comparing Forrest's result with the questionnaire and existing maps results it has been found that Forrest's result are close to the expert's view. Features that have a high percentage of requirement in the questionnaire are generally found in maps based on Forrest's method for all scales and for different levels of detail. After comparing all the results with the selection features, Forrest's formula seems to work for the studied scales.

During this research the data collected for some topics like communication was sufficient, but it was not for other topics like relief. Thus the reliability of the research results are not equal for all map topics. Also, the questionnaire replies were too few to provide very reliable information.. Furthermore, some features were missing in the existing maps studied (e.g. a map with no coastline) which affected on the inclusion score. This is because the geographical area does not have these features, like lakes and rivers. For all these reasons and after comparing all the results, the final knowledge base has been modified with the aim of becoming closer to the correct values, so that maps can be produced which include all the features needed for the map topic, map scale and required level of detail.

After these comparisons and by using the modified data all the features and sub features have been selected for the studied topics. Then by using ArcGIS and Strategi digital map data, the features classes selected using the knowledge base and selection index procedure were used to produce example maps.

Looking at the example maps, some of the them are crowded with base information, but all the features included are deemed essential according to the knowledge base and selection formula. Initially some maps are nearly empty but there are no missing features, although this is often less apparent when they are reduced to the target scale. To some extent this is explained by the weight given to the desired level of detail in the map being produced, but further testing including the topic information to produce final maps would indicate if these results are satisfactory or if the method needs further modification.

After applying all the base information within the GIS and producing an automated map, an automated system could be created by using a VBA script which will help the user or the map maker in choosing the data and designing the map for the required level of detail, desired scale, and necessary topic. This could be done after sending all the final results to expert cartographers again and have their comments about this knowledge base and its results.

The main aim of this study, was to develop and use a knowledge base of map content to aid in selecting map features. Forrest's selection formula which helps in finding a relation between scale, topic and level of detail has been examined for maps in a large range of scales for a number of topics. The initial results indicate that this approach has been successful, although there remains scope for further refinement of the knowledge base. To make sure that this formula is the right one to use in automated selection map contents, further testing on complete maps should be carried out.

REFERENCES

Arctur, D.K, Zeiler, M. (2005) **Designing Geodatabases: Case studies in GIS data modelling**. New York: ESRI Press.

Beard, K (1997) **Geographic Information Research: Presentations of Data Quality**. London: Taylor and Francis.

Bobzien, M. Burghardt, D. Petzold, I (2005) **Re- Generalization And Construction- Two Alternative Approaches to Automated Incremental Updating in MRDB**. Proceedings, XXII International Cartographic Conference: A Coruna, Spain.

Bossler, J.D. Pendleton, D.L. Swetnam, G.F. Vitalo, R.L. Schwarz, C.R. Alper, S. Danler, H.P. (1988) **Knowledge- Based Cartography: The NOS Experience**. The American Cartographer. Vol. 15, No. 2, pp. 149-161.

Brooks, R (2000) **National Atlas of Canada is Producing The First Map Using Automated Generalization of Framework Data**. Geoaccess Division, Cartouche. No. 39. CCRS.

Burrough, P. A. **(1986) Principles of Geographical Information Systems for Land Resources Assessment.** Oxford: Clarendon.

Buttenfield, B. PP. McMaster, R.B (Eds) (1991**) Map Generalization: Making Rules for Knowledge Representation**. Harlow: Longman.

Buttenfield, B. McMaster, R (1997)**: Formalizing Cartographic Knowledge** in **Couclelis, H. Craglia, m, Geographic Information Research**... London: Taylor and Francis . Chapter thirteen.

Calkins, H. W. Marble, D. F (1987) **The Transition To Automated Production Cartography: Design of The Master Cartographic Database.** The American Cartographer, Vol. 14, pp. 105-119.

Carter, J. R (1988) **The Map Viewing Environmental: A Significant Factor in Cartographic Design**. The American Cartographer. Vol.15, pp. 379-385.

Chrisman, N (1997): **Exploring Geographic Information Systems**. Chichester: John Wiley and Sons, Inc.

Chrisman, N.R. (2002): **Exploring Geographic Information Systems** (Second Edition). New York: John Wiley and Sons, Inc.

Clarke, K. C. (1999). **Getting Started With Geographic Information Systems** (second edition). New Jersey: Prentice- Hall, Inc.

Dent, B. D. (1999) **Cartography: Thematic Map Design** (fifth edition). Boston: WCB/McGraw Hill.

Demers, M. N. (2005) **Fundamentals of Geographic Information Systems.** (third edition). New Mexico: John Wiley and Sons, Inc.

Dorling, D. Fairbairn, D. (1997) **Mapping: Ways of Representing the World.** Harlow: Longman.

Drang, D. E. Edelson, B. Levine, R. I. (1986) **A Comprehensive Guide to AI and Expert Systems** .New York: McGraw- Hill, Inc.

Dueker, K. J. (1979) **Land Resource Information Systems: A Review of Fifteen Years Experience**. Geo- Processing, vol. 1, no. 2, pp. 105-128.

Estes, J. Star, J. (1990) **Geographic Information Systems and Introduction.** London: Prentice- Hall, Inc.

Fitzsimons, D. E. (1985) **Base Data on Thematic Maps**. The American cartographer. Vol.12, No.1.

Forrest, D. (1995). **The Application of Expert Systems to Small Scale Map Design**. Unpublished Ph. D thesis: University of Glasgow.

Forrest, D. (1999a) **Developing Rules for Map Design: A Functional Specification for a Cartographic Design Experts System.** Cartographica. Vol. 36/2, pp. 31-54.

Forrest, D. (1999b) **Geographical Information; Its Nature, Classification and Cartographic Representation.** Cartographic, Vol. 36/3, pp. 31-52.

Forrest, D. (2003) **Automated Selection of Cartographic Base Information for Thematic Maps.** Unpublished paper: University of Glasgow.

Forsyth, R. Naylor, C. (1985) **The Hitch-Hiker's Guide to artificial intelligence**. London: Chapman and Hall.

Frye, C. (2003) **The 1:24,000- Scale Topographic Base Map Data Model.** Cartography and Geographic Information Science, vol. 30. **pp. 163-168.**

Garson, G. D, Biggs, R. S. (1992). **Analytic Mapping and Geographic Databases**. California, SAGE Inc.

Ginsberg, M. (1993) **Essentials of Artificial Intelligence**. San Francisco: Morgan Kaufman, Inc.

Goodchild, M. F. Longley, P. A. Marguire, D. J. Rhind, D. M. (2005) **Geographical Information Systems and Science** (second edition). Chichester: Wiley.

Grelot, J.P (1994) **Cartography In The GIS Age.** The Cartographic Journal, Vol. 31, pp. 56-60.

Huxhold, W.E (1991) **An Introduction to Urban Geographic Information Systems.** Oxford: Oxford University Press, Inc.

Joao, E. M. (1998). **Causes and Consequences of Map Generalization**. London: Taylor and Francis.

Johnson, R. D. Muller, J. C. Vanzella, L. R. (1986). **Knowledge- Based Approach For Developing Cartographic Expertise**. Canada: Alberta University.

Keates, J.S. (1973) **Cartographic Design and Production.** London: Longman.

Keates, J.S. (1988) **Cartographic Design and Production** (second edition). Harlow: Longman.

Keates, J.S. (1996) **Understanding Maps** (second edition). Harlow: Longman

Kelly, J. (1993). **Artificial Intelligence: A Modern Myth**. Chichester: Ellis Horwood Limited.

Kelmelis, J. (2003) **To the National Map and Beyond.** Cartography and Geographic Information Science, vol. 30, pp. 185-198.

Kraak, M.J. Ormeling, F.J (1996) **Cartographic Visualization of Spatial Data**. Harlow: Addison Wesley Longman Limited.

Kraak, M. J. Ormeling, F. (2003) **Cartography Visualization of Geospatial Data** (second edition). Harlow: Pearson Education Limited.

Lagrange, J. P. (1997)**: Generalization: Where Are We? Where Should We Go?** in **Couclelis, H. Craglia, m, Geographic Information Research**. London: Taylor and Francis. Chapter twelve.

Luis M.T.de Carvalho, Jan G. P. W. Clevers, Andrew k. Skimore, Steven M. de Jong (2004) **Selection of imagery data and classifiers for mapping Brazilian semideciduous Atlantic forests**. International journal of applied earth observation and geoinformation. Vol.5, pp. 173-186.

Marble, D.F. (1987) **The Computer And Cartography.** The American Cartographer. Vol. 14, pp. 101-103.

Morehouse, S. (1995) **GIS and Generalization: GIS- Based Map Compilation and Generalization.** London: Taylor and Francis.

Muehrcke, P. Muehrcke, J. (1992) **Map Use: Reading, Analysis, and Interpretation (third edition).** Madison, Wis: JP Publications.

Raper, J. (1997)**: Progress towards Spatial Multimedia** in **Couclelis, H. Craglia, m, Geographic Information Research**. London: Taylor and Francis . Chapter thirty-five.

Richardson, D. E. (1988) **Data Base Design Considerations for Rule-Based Map Feature Selection**. ITC Journal 1988, No. 2, pp. 165-171.

Richardson, D. E. (1989) **Rule Based Generalization for Base Map production**. Proceedings, Challenge for the 1990's: geographic information systems 1990, Ottawa, Canada..

Richardson, D. E. (1996) **Generalization of Spatial and Thematic Data Using Inheritance and Classification and Aggregation Hierarchies**. London: Taylor and Francis.

Robinson, A.H. Sale, R.D. (1969) **Elements of Cartography** (third edition). London: Wiley.

Robinson, A.H. Sale, R.D, Morrison, J.L. (1978) **Elements of Cartography** (fourth edition). Chichester: Wiley.

Robinson, A.H. Sale, R.D. Morrison, J.L, Muehrcke, PH.C. (1984) **Elements of Cartography** (fifth edition). New York: Wiley.

Robinson, A.H. Guptill, S.C. Kimerling, A.J. Morrison, J.L. Muehrcke, P.C. (1995) **Elements of Cartography** (sixth edition). Chichester: Wiley.

Schuurman, N (2004) **GIS : A Short Introduction**. Malden, Ma.: Blackwell Publishing Ltd.

Timpf, S. (1997) Geographic **Information Research: Cartographic Objects in a Multi-Scale Data Structure**. London: Taylor and Francis.

Thomson, R.C. Richardson, D.E (1999) **The Good Continuation Principle of Perceptual Organization Applied to The Generalization of Road Networks.** Proceedings, 19th International Cartographic Conference, Ottawa.

Tomlin, C.D. (1990) **Geographic Information Systems and Cartographic Modeling.** London: Prentice- Hall, Inc.

Tomlinson, R.F (1988) **The Impact of The Transition From Analogue to Digital Cartographic Representation**. American Cartographer, Vol.15/1. pp. 249-260.

Topfer, F. Pillewizer, W. (1966) **The Principles of Selection**. The Cartographic Journal. Vol.3, no.1., pp. 10-16

Waterman, D. A. (1986) **A Guide to Expert Systems**. Reading, Ma: Addison-Wesley, Inc.

Worboys, M. Duckham, M. (2004) **GIS A Computing Perspective** (Second edition). Florida: CRC Press LLC.

Yu Zhou. (1993) **The Effects of Scale Change on Map Structure**. Unpublished PhD thesis: Clark University.

Esri, 2005. Merdian 2 User Guide. www.esri.com. (accessed 10.06.2005).

Esri, 2003. Strategi User Guide. www.esri.com. (accessed 16.01.2005).

Edina<http://digimap.edina.ac.uk/main/help/index.jsp?file=data%2farcview%2fmmschema> (accessed 29.08.2005).

Appendix A

MAP DETAILS:

1. Scotland touring map (youth hostel)
    - Scale: 1/570.240 9 miles: 1 inch
    - John Bartholomew and Son ltd.

2. Scotland touring map (Scottish tourist board publication)
    - Scale: 1/316.800 5 miles: 1 inch
    - Prepared for the Scottish Tourist Board by John Bartholomew and Son ltd 1988.

3. Scotland (leisure map touring)
    - Scale: 1/500.000
    - Cartography prepared and published by Estate Publications.

4. Phoenix (Arizona)
    - Scale: 1/250.000
    - Prepared by the U.S. Army Topographic Command (BEEE).

5. ISREAL
    - SCALE: 1/250.000
    - Compiled, drawn and printed by the Survey of Israel, 1951.

6. Dehra dun (India and Pakistani)
    - Scale: 1/250.000
    - Printed, prepared and compiled by Army Map Service Corps of Engineers. U.S. Army 1954

7. Canada land inventory (soil capability for agriculture)
    - Scale: 1/250.000
    - Roger Duhamel. F.R.S.C. Queen's printer and controller of stationery, Ottawa, Canada 1968.

8. Great Britain (road map)
    - Scale: 1/625.000
    - Designed and produced for the RAC by Map Production ltd.

9. Bretagne (France tourism)
    - Scale 1/250.000

10. South west Scotland
    - Scale: 1/253.440 (4 miles: 1 inch)
    - John Bartholomew and Son ltd.

11. Scotland (tourist)
    - Scale: 1/500.000 (8 miles: 1 inch)
    - Made and published by the Ordnance Survey, 1988

12. Scotland (visitor map)
    - Scale: 1/550.000 (9 miles: 1 inch).
    - Bartholomew.

13. Denmark
    - Scale: 1/200.000

14. Bremen
    - Scale: 1/250.000

15. Inland waterways of Britain.
    - Scale: 1/625.000
    - Designed and produced by GEO projects (UK) limited

16. Collin route planner Britain
    - Scale: 1/000.000 (10 miles: 1 inch)

17. Route planner map north Great Britain
    - Scale: 1/625.000
    - Made, printed and published by Ordnance Survey, Southampton, UK.

18. Route planner motoring map of Great Britain
    - Scale: 1/625.000(10 miles to 1 inch)
    - Revised and published annually by the Ordnance Survey, Southampton.

19. Wales and west midlands width of road map
    - Scale: 1/316.800(5 miles to 1 inch)

20. South and east England
    - (Esso road map) touring map
    - Scale: 1/000.000 (5 miles to 1 inch)
    - Prepared and printed by Edward Standford ltd for the Esso Petroleum Company ltd.

21. North Scotland (road map)
    - Touring service - Esso
    - Scale; 1/000.000 (6 miles to 1 inch)
    - Prepared and printed by Edward Standford ltd for the Esso Petroleum Company ltd.

23. Southern Scotland and border counties (width of road map)
    - Scale; 1/316.800 (5 miles to 1 inch)
    - Based on the Ordnance Survey map.

24. Great Britain
    - Scale 1/625.000 (10 miles to 1 inch)
    - Printed and published by the Ordnance Survey, chessington

25. Great Britain
    - Scale: 1/253.440 (4 miles to 1 inch)
    - Printed and published by John Bartholomew and son ltd.

26. Britain the tourist road map
    - Scale 1/570.240
    - Printed by John Bartholomew and son ltd.

51. Scotland.
    - Scale: 1/1000.000
    - Made and published by the Ordnance Survey great Britain

52. England, Wales and Northern Ireland
    - Scale: 1/1000.000
    - Published by the Ordnance Survey Great Britain

53. Great Britain (route planner map south travel master)
    - Scale: 1/625.000

- Made, printed and published by the Ordnance Survey Southampton, UK.

54. Great Britain route planner map north
    - Scale: 1/625.000
    - Made, printed and published by the Ordnance Survey great Britain.

55. Firth of forth
    - Scale: 1/250.000
    - Made and published by the director general of the Ordnance Survey. Southampton

56. Land's end (sea bed sediments)
    - Scale: 1/250.000
    - British geographical survey
    - Made and published by the ordnance survey, Southampton.

57. Little sole bank
    - British geographical survey
    - Scale: 1/250.000
    - Made and published by the Ordnance Survey. Southampton

58. CAYENNE
    - Scale: 1/1000.000
    - Compiled and drawn by the American Geographical Society of New York
    - Reproduced and printed by A.Hoen and company, Baltimore

59. TERNATE
    - SCALE: 1/1000.000
    - Prepared under the direction of the Department of Defense and published by the U.S Army Topographic Command Washington, D.C.

60. OOST BORNEO
    - Scale: 1/1000.000
    - Prepared under the direction of the chief of engineers, U.S. army
    - Published by the Army Map Service, U.S.Army Washington, D.C

61. MEDAN
    - SCALE; 1/1000.000
    - Prepared by the army map service (LU). Corps of Engineers, US Army. Washington, D.C.
    - Published by D.Survey Ministry of Defence, United Kingdom.

62. ENTEBBE
    - Scale; 1/1000.000
    - Reprinted from M.D.R
    - Reproduced by War Office

63. STANLEYVILLE
    - Scale 1/1000.000
    - Published by War Office, Geographical Section, General Staff

64. LIBREVILLE
    - SCALE: 1/1000.000
    - Reproduced from a French map dated. Geographical Section, General Staff, War Office.

65. PICO DA NEBLINA
    - Scale: 1/1000.000
    - Map of the setentrional region of Brazil, first Brazilian

- Printed by IBGE
- Produced by secretaria de planejamento

66. CALI
- Scale: 1/ 1000.000
- Compiled and drawn by the American Geographical Society of New York
- Reproduced by A HOEN and company BALTIMORE

67. PORT- ETIENNE
- Scale: 1/1000.000
- Geographical Section, General Staff, War Office, second edition

68. DAMAS
- Scale: 1/1000.000
- Published by D.survey, War Office and Air Ministry
- Printed by SPC.RE

69. OUARGLA
- Scale: 1/1000.000
- Published by Institute Geographique National

70. ALGER
- Scale: 1/1000.000
- compiled, drawing and published by Istitut Geographicque National

71. Ceskoslovenske
- scale: 1/1000.000
- topographic map
- published in 1966

72. Ceskoslovenske
- scale: 1/1000.000
- geology map
- published in 1966

73. Wales
- scale: 1/1000.000
- tramroads map
- published by the University of Wales 1981

74. . Wales
- scale: 1/500.000
- land use map
- published by the University of Wales 1981

75. . Wales
- scale: 1/1000.000
- agricultural land map
- published by the University of Wales 1981

76. . Wales
- scale: 1/500.000
- surface morphology map
- published by the University of Wales 1981

77. . Wales
- scale: 1/500.000
- local government map

- published by the University of Wales 1981

78. . Wales
    - scale: 1/1000.000
    - boundary map
    - published by the University of Wales 1981

79. Wales
    - scale: 1/500.000
    - road map
    - published by the University of Wales 1981

80. Israel
    - scale: 1/250.000
    - topographic map
    - published, drawn and printed by survey of Isreal 1970

81. Israel
    - scale: 1/500.000
    - geological structure map
    - published, drawn and printed by Survey of Israel 1970

82. Israel
    - scale: 1/1000.000
    - tourism map
    - published, drawn and printed by Survey of Israel 1970

83. Israel
    - scale: 1/1000.000
    - historic map
    - published, drawn and printed by Survey of Israel 1970

84. south east England
    - scale: 1/1000.000
    - railway map
    - made and printed in oxford university, London 1963

85. south east England
    - scale: 1/1000.000
    - road map
    - made and printed in oxford university, London 1963

86. south west England
    - scale: 1/500.000
    - topographic map
    - made and printed in oxford university, London 1963

87. Glasgow
    - scale: 1/253.000
    - autimobile of great Britain
    - copyright by john Bartholomew &son.

88. southern Scotland
    - scale: 1/316.800
    - prepared and printed by Edward Stanford ltd .

89. geological survey of Great Britain
    - scale: 1/253.440

- engraved and published at the O.S, office , Southampton.

90. administrative areas for south
    - scale: 1/625.000
    - published by the O.S.

91. geological map of great Britain
    - scale: 1/625.000
    - published by the O.S.

92. south west Scotland
    - scale: 1/250000.
    - Soil survey of Scotland
    - Made and published by the O.S, Southampton.

93. south west Scotland
    - scale: 1/250000.
    - Soil survey of Scotland
    - Made and published by the O.S, Southampton.

94. the soils of north east Scotland
    - scale: 1/250.000
    - based map compiled from 1/250.000 O.S. head of soil survey, R Glentworth, soil survey cartographers, W.S. Shirreffs & A.D. Moir

95. Scotland
    - Scale: 1/500.000
    - Made and published by the ordnance survey.

96. Scotland & England
    - scale: 1/500.000
    - made and published by the ordnance survey.

97. Scotland
    - Scale: 1/1000.000
    - made and published by the ordnance survey.

98. Scotland
    - Scale: 1/625.000
    - Assessment of climatic conditions in Scotland
    - Base map prepared from the O.S map.
    - Printed by G Cornwall & sons. Aberdeen.
    - Based on accumulated temperature and potential water deficit.

99. Scotland
    - Scale: 1/625.000
    - Assessment of climatic conditions of Scotland
    - Based on exposure and accumulated frost

100. Scotland
    - Scale: 1/625.000
    - Hydrogeological map of Scotland
    - British geological survey
    - The base map is produced from O.S maps
    - Printed by Cook, Hammond and Kell LTD. London.

101. river quality map of Scotland
    - scale: 1/625.000

- printed by john Bartholomew and sons ltd.

102. Scotland population distribution
- Scale: 1/500.000
- Designed and drawn by M.wood and J.S. keates in the cartographic laboratory, department of cartographic , university of Glasgow
- Published by William Collins, and sons ltd and the university of Glasgow.

103. France
- scale: 1/500.000
- hydrographic map

104. France
- scale: 1/1000.000
- population map

105. France
- scale: 1/500.000
- population map

106. France
- scale: 1/500.000
- vegitation map

107. France
- scale: 1/500.000
- urban map

108. Roamain
- scale: 1/1000.000
- administrative map

109. Roamain
- scale: 1/1000.000
- administrative map

110. Roamain
- scale: 1/1000.000
- geological map

111. Roamain
- scale: 1/1000.000
- hydrographice map

112. Roamain
- scale: 1/1000.000
- soil map

113. Roamain
- scale: 1/1000.000
- vegitation map

114. Roamain
- scale: 1/1000.000
- geographic map

115. Roamain
- scale: 1/1000.000

- road map

116. Roamain
- scale: 1/1000.000
- economic map

117. Wales
- scale: 1/500.000
- relief and drainage map
- published by the University of Wales 1981

118. Wales
- scale: 1/500.000
- surface morphology map
- published by the University of Wales 1981

119. Wales
- scale: 1/500.000
- protected land map
- published by the University of Wales 1981

120 . Wales
- scale: 1/500.000
- local government map
- published by the University of Wales 1981

121. Hydrographical map of Scotland
- scale: 1/625.000
- The base map reproduced from Ordnance Survey maps.
- Published in 1988 by Mr F G Larminie

122. Assessment of climatic conditions in Scotland
- scale: 1/625.000
- The base map reproduced from Ordnance Survey maps.
- printed by G . Cornwall & Sons. Aberdeen.

123. Scotland population distribution
- scale: 1/500.000
- edited by J.B. Caird and D. R. Diamond
- reproduced and printed by Higginson- Harris limited

124. map of Scotland
- scale: 1/380.000
- published by the Chart Publishing Co, Oxford.

125. the Southern Islands
- scale: 1/253.440
- printed at the Ordnance Survey Office Southampton, published by Colonel E. M. Jack

126. the Southern Islands
- Scale: 1/253.440
- Published by the Director General at the Ordnance Survey Office Southampton

127. the Southern Islands
- scale: 1/253.440
- printed at the Ordnance Survey Office Southampton and published by the Colonel D. A. Johnston, R.E. Director General

128. Scotland
- scale: 1/250.000
- made & published by the Director General of the Ordnance Survey Office Southampton

129. geological survey of Great Britain (Scotland)
- scale: 1/253.440
- published by the Director General of the Ordnance Survey Office Southampton

130. Scotland
- scale: 1/250.000
- made & published by the Director General of the Ordnance Survey Office Southampton

131. Scotland
- scale: 1/1000.000
- made & published by the Director General of the Ordnance Survey Office, Great Britain

132. England, Wales & Northern Ireland
- scale: 1/1000.000
- made & published by the Director General of the Ordnance Survey Office, Great Britain

133. Finland
- scale: 1/1000.000
- vegetation and distribution of population
- published by the geological society of Finland, 1928

134. Nederland
- scale:1/1000.000
- economic map

135. Nederland
- scale: 1/1000.000
- cultural map

136. Nederland
- scale: 1/1000.000
- land use map

137. Nederland
- scale: 1/1000.000
- population map

138. Nederland
- scale: 1/1000.000
- land cover map

139. Nederland
- scale: 1/1000.000
- water map

140. Ireland
- scale: 1/1250.000
- relief and drainage
- Map prepared and printed by George Philip and son , London

141. Ireland

- scale: 1/1000.000
- solid geology
- Map prepared and printed by George Philip and son , London

142. Ireland
- scale: 1/1250.000
- geomorphology map
- Map prepared and printed by George Philip and son , London

143. Ireland
- scale: 1/1250.000
- land use map
- Map prepared and printed by George Philip and son , London

144. Ireland
- scale: 1/1250.000
- vegetation map
- Map prepared and printed by George Philip and son , London

145. Ireland
- scale: 1/1000.000
- distribution of population
- Map prepared and printed by George Philip and son , London

146. Romania
- scale: 1/1000.000
- geomorphology map

148. Romania
- scale: 1/1000.000
- land cover map

149. Romania
- scale: 1/1000.000
- population map

150. Poland
- scale: 1/200.000
- land use map
- published by the Surveyor General of Poland, Warsaw

151. Poland
- scale: 1/1500.000
- land use map
- published by the Surveyor General of Poland, Warsaw

152. Poland
- scale: 1/1500.000
- natural – forest regions map
- published by the Surveyor General of Poland, Warsaw

153. Poland
- scale: 1/1500.000
- potential natural vegetation map
- published by the Surveyor General of Poland, Warsaw

154. Poland
- scale: 1/1500.000

- fresh ground waters map
- published by the Surveyor General of Poland, Warsaw

155. Poland
- scale: 1/500.000
- urban agglomerations map
- published by the Surveyor General of Poland, Warsaw

156. Poland
- scale: 1/1500.000
- distribution of population map
- published by the Surveyor General of Poland, Warsaw

157. Poland
- scale: 1/1500.000
- landscape use map
- published by the Surveyor General of Poland, Warsaw

158. Poland
- scale: 1/1500.000
- environmental degradation map
- published by the Surveyor General of Poland, Warsaw

159. Poland
- scale: 1/1500.000
- surface water map
- published by the Surveyor General of Poland, Warsaw

160. Poland
- scale: 1/1500.000
- relief origin map
- published by the Surveyor General of Poland, Warsaw

161. Poland
- scale: 1/1500.000
- administrative division map
- published by the Surveyor General of Poland, Warsaw

162. Poland
- scale: 1/1250.000
- main cities and urban complexes map
- published by the Surveyor General of Poland, Warsaw

163. Colombia
- scale: 1/700.000
- administrative map
- printed in Colombia 1977

164. Administrative area diagram
- scale: 1/100.000
- made and published by the Director General of the O.S. Southampton

165. Bedfordshire (administrative)
- scale: 1/100.000
- made and published by the Director General of the O.S. Southampton

166. Administrative area diagram (Scotland)
- scale: 1/250.000

- made and published by the Director General of the O.S . Southampton

167. Denmark
- scale: 1/500.000
- road map
- made in Cartographic Section Kobenhavn

168. Netherland
- scale: 1/600.000
- geomorphology map
- printed by the Topographic Service Delft, 1974

169. Nigeria (western state savanna soil survey)
- scale: 1/500.000
- relief map
- published for the Nigeria government by the British Government's Ministry of Overseas Development

170. Lesotho highlands
- scale: 1/300.000
- water map
- made by the Lesotho highlands development authority

171. Norway Norge
- scale: 1/1000.000
- touring map

172. Maryland
- scale: 1/380.160
- road map
- published for free distribution by Maryland department of transportation

173. western new England
- scale: 1/614.600
- produced by the cartographic division, national geographic society Washington 1975

174. Germany
- scale: 1/1000.000
- road map

175. Suisse
- scale: 1/520.000
- tour map
- printed in Switzerland

176. Allemagne (south west Germany)
- scale: 1/300.000
- road map

177. France (Lorraine Alsace sarre)
- scale: 1/250.000
- road map

178. Prince Edward Island
- scale: 1/250.000
- land capability for forestry
- base map printing by the Surveys Mapping Branch, Department of Energy, Mines and Resources, Ottawa 1969

179. Mexico
- scale: 1/1000.000
- tourist map
- printed by the Direction General san Antonio 1979

180. Germany
- scale: 1/800.000
- road map

181. The Mid-Atlantic States
- scale: 1/886.000
- produced by the Cartographic Division, National Geographic Society

182. Norge- Norway
- scale: 1/500.000
- geographic map

183. Nootka- Nanaimo
- scale: 1/500.000
- base map supplied by the Geographical Services Directorate, Surveys and Mapping Branch, Department of Energy, Mines and Resources, Ottawa

184. Southern New England
- scale: 1/430.000
- road map
- copyright by Rand McNally & company

185. Kitimat- Stikine (regional district)
- scale: 1/500.000
- made by the Canadian Cartographic Ltd, 1978

186. Lake Simcoe land capability for wildlife- waterfowl
- scale: 1/250.000
- printed by the Surveys and Mapping Branch, Department of Energy, Mines and Resources, Ottawa, 1970

187. Topomrphic map of Northern Afar (Ethiopia)
- scale: 1/250.000
- made by geo map (Florence, Italy) with the permission of Mobile Petroleum Ethiopia inc and Esso Exploration inc

atlases details:

1. atlas regional des pays de la loire (1973)
   published by Techni p, Paris
2. Romania atlas (1979)
3. National Atlas of Wales (1981),
   maps drawn by Geoprojects (UK) ltd and the Department of Geography, University College of Wales, Aberystwyth.
4. atlas of the republic of Poland (1997)
   publisher: Surveyor General of Poland, Warsaw.
5. Atlas of Britain 91963).
   Made and printed in Great Britain, Oxford University Press, London.
6. Atlas of Nederland(1984).
7. Atlas of Israel (1970).
   Published, drawn, and printed by Survey of Israel.
8. Atlas Ceskoslovenske Socialisticke Republic (1966).
9. Atlas of Finland 91928).
   The Geographical Society of Finland, Helsinki.

10. Atlas of Ireland 91979).
Maps prepared and printed by George Philip and son, London.
11. Atlas de Colombia (1977).
Printed in Colombia.

Appendix B: collected data from maps at the same scale.

Collected data from existing maps at scale 1:250 000

FEATURES	map number / sub features	2	9	21	25	4	5	6	7	10	13	14	55	20	19	23	92	93	94	87	88	89	80	124
motorways	normal	*	*		*	*			*	*	*		*	*	*	*				*				*
	under construction									*			*	*										
	motorway tunnel		*																					
	full + limited access	*								*						*								
	motorway junction	*				*					*		*			*								*
primary route	primary route	*			*	*			*	*	*		*			*								*
	dual carriageway	*																						
	under construction	*								*														
	single carriageway																							
	tunnel																							
a roads	main road			*	*		*	*		*	*		*	*	*	*				*	*	*	*	
	dual carriageway	*											*											
	under construction										*		*											
	single carriageway												*											
	narrow roads														*									
b roads	secondary roads	*	*	*	*	*	*			*	*		*	*	*	*					*	*	*	
	dual carriageway		*										*											
	narrow road				*								*			*								
minor road	minor road										*		*											
	under construction road																							
	other road	*		*						*	*		*	*	*	*				*	*	*		
	unclassified road																							
additional road	projected by	*								*														

features	pass roads																						
	all weather road					*	*				*	*										*	
	dry weather road					*	*	*														*	
	narrow road with passing places												*										
	gradients- sleep	*								*			*		*	*							
	toll	*	*							*			*										
	footpath, trail				*	*		*			*	*								*			
	cart track							*															
	loose surface							*															
	cross road		*					*															
	national road		*																				
railway	standard	*	*		*		*		*	*	*		*				*	*		*		*	*	*
	narrow		*					*				*	*											*
	railway tunnel											*	*							*				*
	single standard		*			*		*				*												
	single narrow					*		*																
	double standard		*			*																		
	double narrow					*																		
	multiple standard					*		*				*												
	multiple narrow					*		*																
	railway station				*								*							*		*		
	tourist railway									*														
water feature	stream and wadi		*			*	*	*															*	
	lake	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*		*	*		*	*
	dam		*								*													
	glacier							*																
	galcial moraine							*																
	spring- well- cistern						*																*	

	cliff-slope						*				*		*											
	foreshore area								*															
	sand dunes						*				*	*											*	
	rock		*							*		*	*											
	mudflat						*																*	
	bridge												*											
	tunnel																							
	canal	*	*		*					*			*							*				
	navigable canal		*									*												
	non navigable canal		*																					
	vehicular ferry	*			*				*	*	*	*	*		*	*				*				
	ferry route link																							
	passenger ferry	*									*	*	*											
	river/ main	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*		*	*	*	*	*	*
	2nd river	*	*	*	*	*		*	*		*	*			*	*				*	*	*		*	
	marsh- swamp		*			*	*	*		*	*	*	*											*	
settlements	city	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	town	*	*	*	*	*	*	*	*		*	*		*	*	*	*	*	*	*	*	*	*	*	*
	2nd town	*	*	*		*	*	*	*		*	*			*		*	*		*			*	*	
	other town	*				*			*							*							*	
	village	*					*		*											*	*			*	
	small villages	*					*		*											*	*			*	
	landmark feature					*	*	*																	
	urban area		*										*		*	*				*	*	*	*		
boundary	national boundary	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*			*		*	*		
	county boundary		*	*	*	*			*	*	*	*	*	*	*	*	*			*	*	*		*	
	state boundary		*			*		*																*	
	district boundary																								
	sub district boundary																								
	national forest park	*								*															

	coastline	*	*	*	*					*				*	*	*	*	*	*	*	*	*	*	*
	national park	*				*			*	*			*	*	*	*					*			
land use	wood forest	*	*	*		*		*		*	*	*	*	*	*	*					*	*		
	orchard					*		*			*													
	mine							*									*	*	*					
	airport	*	*	*		*			*	*	*	*		*	*	*					*		*	
	airfield					*		*	*		*													
	seaplane port					*		*	*			*												
	heliport									*														
	ruin						*																*	
	lighthouse		*						*		*													*
	lightship										*													*
	mound						*																	
	zone						*																*	
tourist features	castle	*		*						*	*			*							*			
	historic house	*								*														
	park- garden	*								*	*											*		
	cathedral	*			*	*	*			*	*			*						*	*	*	*	
	battle site	*		*						*			*	*			*	*	*		*			
	nature reserve	*								*	*													
	wildlife park	*								*														
	information centre	*	*							*	*													
	golf course	*	*							*	*													
	youth hostel	*	*							*	*													
	motor racing centre									*														
	race course	*								*	*				*	*								
	camping- caravanning									*	*													
	cave		*																					
	museum- theatre	*	*								*													
	nature or forest trail																							

	skiing																							
	railway																							
	zoo																							
	other tourist feature	*	*							*	*										*		*	
	antiquities												*										*	
topographic features	horizonal control																							*
	point(spot high)																						m	
	distance	mi	km			mi		mi		mi					mi	mi								
	submarine contours												*											
	contours				*	*	*						*				*	*		*			*	
	mileage																							*
	height	mi		f	feet	f	f	f		mi				f						f	f			
populated places			*	*		*		*				*		*										

FEATURES	map number / sub features	125	126	127	128	129	130	150	162	164	165	166	170	172	176	177	178	186	187
motorways	normal	*	*	*		*			*	*	*	*	*	*	*	*	*		*
	under construction													*					
	motorway tunnel																		
	full + limited access																		
	motorway junction		*	*		*			*	*	*		*	*	*	*	*		*
primary route	primary route	*	*	*		*			*	*	*		*	*					*
	dual carriageway													*					
	under construction																		
	single carriageway													*					
	tunnel																		
a roads	main road	*	*	*		*							*	*	*	*			*

	dual carriageway								*						*				
	under construction																		
	single carriageway																		
	narrow roads																		
b roads	secondary roads	*	*	*		*			*					*	*	*			
	dual carriageway														*				
	narrow road																		
minor road	minor road								*										
	under construction road																		
	other road	*	*	*		*			*				*	*	*	*	*		
	unclassified road														*				
additional road features	projected by pass roads																		
	all weather road																	*	
	dry weather road																	*	
	narrow road with passing places																		
	gradients- sleep														*				
	toll														*	*			
	footpath, trail														*	*		*	*
	cart track														*				
	loose surface																		
	cross road																		
	national road															*			
railway	standard	*	*	*		*			*	*	*	*			*		*	*	*
	narrow																		
	railway tunnel														*	*			
	single standard															*			
	single narrow																		

	double standard														*				
	double narrow																		
	multiple standard																		
	multiple narrow																		
	railway station		*			*			*							*				
	tourist railway																		
water feature	stream and wadi																	*	
	lake	*	*	*		*		*	*				*	*	*	*	*	*	*
	dam																		
	glacier																		
	glacial moraine																		
	spring- well- cistern																		*
	cliff-slope																		
	foreshore area																*		
	sand dunes																*		*
	rock															*			*
	mudflat																		
	bridge																		
	tunnel																		
	canal							*											
	navigable canal															*			
	non navigable canal															*			
	vehicular ferry								*						*		*		
	ferry route link																		
	passenger ferry								*								*		
	river/ main	*	*	*		*		*	*			*	*	*	*	*	*	*	*
	2nd river	*	*	*		*		*	*			*	*	*	*	*	*		
	marsh- swamp							*								*			*
settlements	city	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*
	town	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

	2nd town	*							*					*	*				
	other town													*					
	village	*							*					*	*	*	*		*
	small villages								*						*				
	landmark feature																		
	urban area				*	*	*	*	*	*	*	*	*		*	*		*	*
boundary	national boundary	*		*		*		*			*	*			*		*		*
	county boundary	*	*	*	*	*				*	*	*	*	*	*		*	*	
	state boundary	*			*	*	*		*	*	*	*		*		*			*
	district boundary						*		*				*			*		*	
	sub district boundary																		
	national forest park																*		
	coastline	*	*	*		*	*	*		*		*		*		*	*		*
	national park								*										
land use	wood forest		*					*								*			
	orchard																		
	mine								*										
	airport							*	*				*		*	*	*	*	*
	airfield												*		*	*	*		
	seaplane port																*		
	heliport							*											
	ruin														*	*			
	lighthouse	*														*	*	*	
	lightship	*																	
	mound																		
	zone																		
tourist features	castle														*	*			
	historic house																		
	park- garden													*	*				

	cathedral	*	*	*		*									*		*		
	battle site	*				*													
	nature reserve																		
	wildlife park													*					
	information centre																		
	golf course																		
	youth hostel																		
	motor racing centre																		
	race course																		
	camping-caravanning															*			
	cave															*			
	museum- theatre															*			
	nature or forest trail																		
	skiing																		
	railway																		
	zoo																		
	other tourist feature																		
	antiquities																		
topographic features	horizonal control																*	*	
	point(spot high)								*									*	*
	distance												m		*	km			
	submarine contours																		
	contours	*							*									*	
	mileage													*					
	height																		
populated places																*			

Collected data from existing maps at scale 1:500 000

FEATURES	map number / sub features	1	3	11	12	26	8	16	17	18	24	53	54	15	95	96	98	99	100	101	102	90	91	103	105	106
motorways	normal	*	*	*	*	*	*	*	*	*	*	*	*		*	*		*	*	*		*	*		*	*
	under construction	*		*	*	*	*		*																	
	motorway tunnel				*																					
	full + limited access				*		*	*	*	*		*	*													
	motorway junction						*				*					*		*	*	*			*			*
primary route	primary route	*	*	*	*	*	*	*	*	*	*					*		*		*		*	*		*	*
	dual carriageway						*					*	*													
	under construction						*					*	*													
	single carriageway			*								*	*													
	tunnel	*				*																				
a roads	main road	*	*	*	*	*	*	*	*	*	*				*								*			
	dual carriageway							*	*	*		*	*													
	under construction			*	*			*			*	*	*													
	single carriageway			*				*	*	*		*	*													
	narrow roads								*																	
b roads	secondary roads	*	*	*	*	*	*	*	*	*		*	*										*			
	dual carriageway				*		*	*																		
	narrow road					*																				
minor road	minor road						*	*	*			*	*													
	under construction road																									

	other road		*		*		*				*												*				
	unclassified road	*		*		*			*	*		*	*														
additional road features	projected by pass roads	*		*			*																				
	all weather road																										
	dry weather road																										
	narrow road with passing places																										
	gradients- sleep	*			*	*	*		*	*		*	*														
	toll	*			*	*		*	*	*																	
	footpath, trail																										
	cart track																										
	loose surface																										
	cross road																										
	national road																										
railway	standard	*	*	*	*						*				*	*						*	*				
	narrow																										
	railway tunnel										*				*							*	*				
	single standard																										
	single narrow																										
	double standard																										
	double narrow																										
	multiple standard																										
	multiple narrow																										
	railway station										*				*												
	tourist railway								*			*	*														
	stream and wadi										*																
	lake	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*		
	dam				*																						
	glacier																										

	glacial moraine																										
	spring-well-cistern																										
	cliff-slope																										
water feature	foreshore area							*																			
	sand dunes																						*				
	rock																										
	mudflat																										
	bridge																										
	tunnel												*														
	canal			*	*			*	*	*	*	*	*	*						*	*		*	*			
	navigable canal												*														
	non navigable canal												*														
	vehicular ferry	*	*	*	*	*	*	*	*	*		*	*										*				
	ferry route link			*				*																			
	passenger ferry																										
	river/ main	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*	*
	2nd river													*	*	*			*	*	*			*	*	*	*
	marsh-swamp																										
settlements	city	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	town/ large	*		*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*		*		
	2nd town																				*				*		
	others town																					*	*				
	village			*	*				*	*	*	*	*	*	*						*	*	*		*		
	small villages																				*				*		
	landmark feature		*																								
	urban area				*	*		*						*	*	*	*	*	*	*	*	*	*	*			*
boundary	national boundary	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*		*		
	county boundary			*			*	*		*	*				*		*	*	*	*	*	*	*	*	*	*	*

	state boundary																*	*	*		*						
	district boundary																					*					
	sub district boundary																										
	national forest park			*	*		*																				
	coastline	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	national park		*		*		*																				
land use	wood forest																										
	orchard																										
	mine																										
	airport	*	*	*	*	*	*	*	*	*		*	*														
	airfield						*																				
	seaplane port																										
	heliport																										
	ruin																										
	lighthouse										*																
	lightship										*																
	mound																										
	zone																										
tourist features	castle																										
	historic house																										
	park- garden																										
	cathedral						*																				
	battle site																										
	nature reserve																										
	wildlife park																										
	information centre						*																				
	golf course																										
	youth hostel																										

	motor racing centre																									
	race course																									
	camping-caravanning																									
	cave																									
	museum- theatre																									
	nature or forest trail																									
	skiing																									
	railway																									
	zoo																									
	other tourist feature						*							*												
	antiquities																									
geographic point	horizonal control																									
	point(spot high)														*	*	*									
	distance						mi	mi	mi					mi												
	submarine contours																									
	contours														*	*			*							
	mileages															*										
	height						feet	f		m				f			m	m				f	f			
populated places																										
telephone call box							*			*																

FEATURES	map number / sub features	107	117	118	79	119	120	81	86	74	76	77	121	122	123	163	155	167	168	169	173	175	182	183	184	185
motorways	normal				*	*		*	*	*		*		*		*		*	*	*	*	*	*		*	*
	under construction																					*	*		*	
	motorway tunnel				*																					
	full + limited access																	*					*		*	
	motorway junction					*		*				*		*				*	*	*					*	
primary route	primary route					*		*				*		*				*	*	*		*				*
	dual carriageway																									
	under construction																									
	single carriageway																									
	tunnel																					*				
a roads	main road				*				*							*		*		*		*	*	*	*	*
	dual carriageway																									
	under construction																						*			
	single carriageway																									
	narrow roads																									
b roads	secondary roads				*				*									*		*			*	*	*	*
	dual carriageway																									
	narrow road																									

minor road	minor road																									
	under construction road																									
	other road				*													*			*	*	*	*		*
	unclassified road																									
additional road features	projected by pass roads																									
	all weather road																						*			
	dry weather road																									
	narrow road with passing places																									
	gradients-sleep																									
	toll				*						*															
	footpath, trail																				*		*			
	cart track																									
	loose surface																									
	cross road																									
	national road																					*				
railway	standard								*							*		*		*	*	*		*		*
	narrow																									
	railway tunnel																					*	*			
	single standard																						*			
	single narrow																						*			
	double standard																						*			
	double narrow																						*			
	multiple																									

	standard																										
	multiple narrow																										
	railway station																						*				
	tourist railway																										
	stream and wadi										*		*						*								
	lake		*	*		*		*		*	*		*		*	*	*	*	*	*	*	*	*	*	*	*	*
	dam																						*				
	glacier										*												*				
	glacial moraine			*							*								*								
	spring-well-cistern																										
	cliff-slope			*							*																
water feature	foreshore area																										
	sand dunes			*							*							*	*								
	rock										*																
	mudflat																	*									
	bridge																						*				
	tunnel																										
	canal			*					*		*		*						*								
	navigable canal																				*		*				
	non navigable canal																						*				
	vehicular ferry								*									*				*	*		*		
	ferry route link																									*	
	passenger ferry																						*			*	
	river/ main	*	*	*		*		*		*	*		*		*	*	*	*	*	*	*	*	*	*	*	*	*
	2nd river		*	*		*							*		*	*	*	*	*		*	*		*	*		
	marsh-swamp																										
	city	*	*		*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

settlements	town/ large	*	*			*	*	*					*	*	*	*	*	*		*	*	*	*	*	*	*
	2nd town	*	*			*	*								*	*		*			*	*	*		*	*
	others town					*																			*	
	village	*	*			*								*	*		*				*	*	*	*	*	*
	small villages	*													*						*		*	*	*	*
	landmark feature																									
	urban area				*		*			*						*			*	*	*		*			*	
boundary	national boundary	*			*		*		*		*	*				*	*	*	*	*	*	*	*	*		*	*
	county boundary	*			*		*		*		*	*						*	*				*				
	state boundary													*	*		*				*	*	*	*		*	
	district boundary						*					*															*
	sub district boundary						*					*															*
	national forest park					*															*	*			*		
	coastline	*	*	*	*		*	*			*		*	*	*	*	*	*	*				*	*	*	
	national park								*																	*	
land use	wood forest								*	*						*		*					*			
	orchard									*																
	mine																						*			*
	airport								*							*		*			*		*		*	*
	airfield																	*				*	*		*	
	seaplane port																						*		*	
	heliport																									
	ruin																									
	lighthouse																						*			
	lightship																									
	mound										*								*							
	zone																									

tourist features	castle																									
	historic house																									
	park- garden									*											*					*
	cathedral																									
	battle site																									
	nature reserve																									
	wildlife park																									
	information centre																									
	golf course																									
	youth hostel																									
	motor racing centre																									
	race course																									
	camping-caravanning																					*			*	
	cave																									
	museum-theatre																									
	nature or forest trail																									
	skiing																									
	railway																									
	zoo																									
	other tourist feature																									
	antiquities																									
geographic point	horizonal control							*																		
	point(spot high)				*			*	*											*	*	*	km	*	*		*
	distance																							km			
	submarine contours																									*	

	contours							*					*			*							*	*		*
	mileages																										
	height				*													m		f							
populated places																											
telephone call box																											

Collected data from existing maps at scale 1:1000 000

FEATURES	map number / sub features	51	52	58	59	60	61	62	63	64	65	66	67	68	69	70	97	73	75	78	82	83	104	108	109	110	111
motorways	normal	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*		*		*	*	*	
	under construction																										
	motorway tunnel																										
	full + limited access																										
	motorway junction	*	*			*		*	*	*	*		*	*	*		*		*	*		*		*	*	*	
primary route	primary route	*	*			*		*	*	*	*		*	*	*		*		*	*		*		*	*	*	
	dual carriageway																										
	under construction										*																
	single carriageway																										
	tunnel																										
a roads	main road	*	*		*		*	*	*	*			*	*		*									*		
	dual carriageway	*	*		*		*				*					*											
	under construction	*	*								*					*											
	single carriageway																										
	narrow roads																										
b roads	secondary roads	*	*		*	*	*		*		*		*	*		*									*		
	dual carriageway																										
	narrow road																										
minor road	minor road																										
	under construction road																										
	other road			*	*		*	*	*		*	*		*		*											
	unclassified road																										
additional road features	projected by pass roads																										
	all weather road									*			*														

	dry weather road																											
	narrow road with passing places																											
	gradients- sleep																											
	toll																											
	footpath, trail			*	*	*	*		*	*	*	*	*	*	*	*												
	cart track																											
	loose surface																											
	cross road																											
	national road																											
railway	standard			*				*	*	*			*		*	*								*	*			
	narrow	*	*		*		*				*	*		*		*												
	railway tunnel	*	*								*			*														
	single standard				*		*				*			*														
	single narrow				*		*				*					*												
	double standard																											
	double narrow																											
	multiple standard	*	*		*		*				*			*														
	multiple narrow				*		*				*					*												
	railway station				*									*														
	tourist railway																											
water feature	stream and wadi				*		*				*			*														
	lake	*	*		*		*	*	*	*	*		*	*		*	*	*				*		*	*	*	*		
	dam										*			*		*												
	glacier																											
	glacial moraine																											
	spring- well- cistern													*	*													
	cliff-slope				*		*	*						*	*	*												
	foreshore area	*	*		*		*				*																	
	sand dunes			*	*	*	*	*		*			*	*	*	*												

	rock						*					*																
	mudflat																										
	bridge																										
	tunnel																										
	canal	*	*	*						*			*		*			*								*	*	*
	navigable canal																											
	non navigable canal																											
	vehicular ferry	*	*				*																					
	ferry route link	*	*																									
	passenger ferry	*	*	*												*												
	river/ main	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*				*	*	*	*	*	*	*	*
	2nd river			*		*						*		*		*	*									*	*	*	*
	marsh- swamp	*	*	*	*	*	*	*		*		*	*	*	*	*											*		
settlements	city	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	town/ large	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*							*	*	*	*	*	*
	2nd town	*	*	*	*		*		*	*	*	*	*	*		*								*	*	*	*	*	*
	other town	*	*	*	*	*	*		*	*	*	*	*	*		*								*	*	*			
	village	*	*	*				*	*	*	*	*	*											*	*	*	*		
	small villages			*								*														*	*		
	landmark feature										*	*																	
	urban area			*				*	*	*	*	*	*	*			*	*	*							*	*	*	*
boundary	national boundary	*	*	*	*	*	*	*		*	*	*	*	*	*	*										*	*	*	*
	county boundary	*	*																	*		*	*	*					*
	state boundary										*									*					*	*			
	district boundary							*		*			*																
	sub district boundary																												
	national forest park																												
	coastline																				*		*	*	*	*	*	*	*
	national park																				*								

land use	wood forest						*	*											*		*				*			
	orchard																		*									
	mine			*	*		*		*		*	*			*	*												
	airport	*	*	*	*	*					*	*		*		*										*		
	airfield																											
	seaplane port				*	*						*		*														
	heliport																											
	ruin				*		*			*	*		*	*	*	*												
	lighthouse	*	*	*	*	*	*			*	*	*	*		*	*												
	lightship																											
	mound																											
	zone										*																	
tourist features	castle																				*							
	historic house																											
	park- garden																		*		*							
	cathedral																				*			*				
	battle site																											
	nature reserve																											
	wildlife park																											
	information centre																				*							
	golf course																											
	youth hostel																											
	motor racing centre																											
	race course																											
	camping- caravanning																											
	cave																				*							
	museum- theatre																											
	nature or forest trail																											
	skiing																											
	railway																											

	zoo																										
	other tourist feature																				*						
	antiquities																										
topographic features	horizonal control				*		*																				
	point(spot high)	*	*		*		*			*	*	*		*	*						*						
	distance							m/f	m																		
	submarine contours																										
	contours	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*											*
	mileages																										
	height					m	m	f		m		m	m														
populated places																											

FEATURES	map number / sub features	112	113	114	115	116	71	72	84	85	131	132	133	134	135	136	137	138	139	140	141	142	143
motorways	normal	*	*	*	*	*	*		*	*	*	*		*	*		*	*		*	*		*
	under construction																						
	motorway tunnel				*																		
	full + limited access																						
	motorway junction		*		*		*		*		*	*		*							*		*
primary route	primary route		*		*		*		*		*	*									*		*
	dual carriageway										*	*											
	under construction										*	*											
	single																						

	carriageway																						
	tunnel																						
a roads	main road				*	*	*			*	*	*		*									
	dual carriageway																						
	under construction																						
	single carriageway																						
	narrow roads									*													
b roads	secondary roads				*		*			*	*	*		*									
	dual carriageway																						
	narrow road																						
minor road	minor road				*																		
	under construction road																						
	other road									*													
	unclassified road																						
additional road features	projected by pass roads																						
	all weather road																						
	dry weather road																						
	narrow road with passing places																						
	gradients- sleep																						
	toll																						
	footpath, trail																						
	cart track																						
	loose surface																						
	cross road																						
	national road																						

railway	standard					*	*		*														
	narrow										*	*											
	railway tunnel								*		*	*											
	single standard																						
	single narrow										*	*											
	double standard																						
	double narrow										*	*											
	multiple standard																						
	multiple narrow										*	*											
	railway station																						
	tourist railway																						
water feature	stream and wadi																						
	lake	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*
	dam																						
	glacier																						
	glacial moraine																					*	
	spring- well-cistern																						
	cliff-slope																					*	
	foreshore area										*	*								*			
	sand dunes																					*	
	rock												*										
	mudflat																					*	
	bridge																						
	tunnel																						
	canal	*	*	*	*	*					*	*								*			
	navigable canal																						
	non navigable canal																						
	vehicular ferry										*	*											

	ferry route link								*														
	passenger ferry										*	*											
	river/ main	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*
	2nd river	*	*	*	*	*	*				*	*	*	*	*	*	*	*	*	*		*	*
	marsh- swamp						*				*	*	*					*	*				
settlements	city	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*
	town/ large	*	*		*	*	*	*	*	*	*	*	*				*				*		*
	2nd town	*	*				*				*	*	*				*						
	other town						*				*	*	*				*						
	village	*	*				*		*		*	*	*				*						
	small villages						*				*	*	*				*						
	landmark feature																						
	urban area	*	*	*	*				*	*				*	*	*	*						*
boundary	national boundary	*	*	*	*	*					*	*	*										
	county boundary	*	*		*		*	*			*	*											
	state boundary						*	*					*	*		*							
	district boundary																						
	sub district boundary																						
	national forest park																						
	coastline	*	*	*	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	national park																						
land use	wood forest												*		*			*					
	orchard																						
	mine																						
	airport									*	*	*											
	airfield										*	*											
	seaplane port																						
	heliport																						

	ruin																							
	lighthouse										*	*												
	lightship																							
	mound																							
	zone																							
tourist features	castle																							
	historic house																							
	park- garden																							
	cathedral																							
	battle site																							
	nature reserve																							
	wildlife park																							
	information centre																							
	golf course																							
	youth hostel																							
	motor racing centre																							
	race course																							
	camping- caravanning																							
	cave																							
	museum- theatre																							
	nature or forest trail																							
	skiing																							
	railway																							
	zoo																							
	other tourist feature																							
	antiquities																							

topographic features	horizonal control																						
	point(spot high)				*		*				*	*	*										
	distance																						
	submarine contours																						
	contours						*				*	*											
	mileages																						
	height										m	m											
populated places																							

FEATURES	map number / sub features	144	145	146	148	149	151	152	153	154	156	157	158	159	160	161	171	174	179	180	181
motorways	normal	*		*			*		*			*		*				*	*	*	*
	under construction																	*		*	
	motorway tunnel																			*	
	full + limited access																				
	motorway junction	*					*		*			*		*						*	
primary route	primary route	*					*		*			*		*							
	dual carriageway																				
	under construction																				
	single carriageway																				
	tunnel																				
a roads	main road																*	*	*	*	
	dual carriageway																	*			
	under construction																			*	
	single carriageway																				
	narrow roads																				
b roads	secondary roads																*	*	*	*	

	dual carriageway																	*				
	narrow road																					
minor road	minor road																			*		
	under construction road																					
	other road																*	*		*	*	
	unclassified road																					
additional road features	projected by pass roads																					
	all weather road																		*			
	dry weather road																					
	narrow road with passing places																					
	gradients- sleep																					
	toll																	*				
	footpath, trail																					*
	cart track																					
	loose surface																					
	cross road																					
	national road																					
railway	standard																	*		*	*	*
	narrow																					
	railway tunnel																					
	single standard																					
	single narrow																					
	double standard																					
	double narrow																					
	multiple standard																					
	multiple narrow																					
	railway station																					

	tourist railway																				
water feature	stream and wadi																				
	lake	*	*	*	*	*	*			*	*			*	*		*	*	*	*	*
	dam													*				*			
	glacier														*						
	galcial moraine																				
	spring- well- cistern																				
	cliff-slope														*						
	foreshore area																				
	sand dunes																				
	rock																				
	mudflat																				
	bridge																				
	tunnel																			*	
	canal																				*
	navigable canal													*							
	non navigable canal																				
	vehicular ferry																*	*	*	*	
	ferry route link																				
	passenger ferry																				
	river/ main	*	*	*	*	*	*	*		*	*		*	*	*		*	*	*	*	*
	2nd river	*	*	*	*	*	*	*		*	*		*	*	*		*	*	*	*	*
	marsh- swamp				*		*		*					*						*	*
settlements	city	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	town/ large	*	*	*	*	*	*	*	*		*					*	*	*	*	*	*
	2nd town		*			*					*					*	*	*	*	*	
	other town		*	*		*					*							*		*	
	village		*	*		*					*					*	*	*	*	*	
	small villages		*			*					*							*		*	

	landmark feature																				
	urban area	*	*		*		*	*	*	*	*	*		*	*	*	*	*			
boundary	national boundary			*	*	*	*	*	*	*	*	*	*	*	*	*	*		*		
	county boundary															*					*
	state boundary				*	*		*								*			*		
	district boundary															*	*	*			
	sub district boundary																				
	national forest park							*													*
	coastline	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*
	national park											*								*	*
land use	wood forest				*		*		*			*	*	*						*	
	orchard											*									
	mine																				
	airport																*	*	*	*	*
	airfield																		*	*	
	seaplane port																				
	heliport																				
	ruin																	*		*	
	lighthouse																				
	lightship																				
	mound																				
	zone												*								
tourist features	castle																				
	historic house																		*		
	park- garden																		*		
	cathedral																*			*	
	battle site																				
	nature reserve																				

	wildlife park																		*		*
	information centre																				
	golf course																				
	youth hostel																				
	motor racing centre																				
	race course																				
	camping-caravanning																		*		
	cave																		*		
	museum- theatre																		*		
	nature or forest trail																				
	skiing																				*
	railway																				
	zoo																				
	other tourist feature																		*		
	antiquities																		*		
topographic features	horizonal control																				
	point(spot high)																				
	distance																		*		
	submarine contours																				
	contours																	*			
	mileages																				
	height																	m			
populated places																					

questionnaire										
evaluation										
FEATURES	sub features	topographic	political	population	land use	relief	land cover	climate	communication	environmental science
limited access highways(motorways)	carriageways									
	junction/ slip road detail									
major road	key primary routes									
	all dual and single carriageway									
secondary road	secondary roads									
minor road	other road (surfaced)									
	unclassified road or track									
additional road features	gradients- steep									
	toll									
	footpath, trail									
water feature	major lake									
	minor lake									
	canal									
	major river									
	2nd class river									
	3rd class river									
	large area of marsh or swamp									
settlements	city									
	town									
	village									
	isolated group of buildings									
boundary	national boundary									
	first level internal boundary									
	second level internal boundary									
	coastline									
	national or regional park									
land cover	wood / forest									
	plantation or cultivated area									
	extensive non vegetated area									
other features	major historic/ cultural site									
	landmark									
topographic features	key spot heights									
	general relief information									
	detail height information									
transport	vehicular ferry									
	passenger ferry									
	main line railway									
	other railway									
	airport									

E: essential	E
D: desirable	D
Q: questionable	Q
U: unnecessary	U

map topics

topographic: topographic and geographic maps
political: boundary and administrative maps
population: population maps (e.g. census maps)
land use: cultural and economic aspects of land
relief
environmental: hydrography, geology, soils, geomorphology, etc
communication: tourist and road maps
climate: rainfall and temperature maps
land cover: vegetation and land cover type maps

definition of feature classes

major river: navigable river 2nd class river: non- navigable, significant 3rd class river: non- navigable small river

major lake> 1 cm^2 at base scale minor lake<1 cm^2 at base scale

city: more than 200,000
Large town: 200,000- 5,000
village: 5,000- 2,00
isolated group of buildings: settlement or small group of buildings significant in the landscape or administrative importance

Occupation/ job title:

Are you primarily?

- ☐ 1. Designer or Producer of maps
  - ☐ Wide range of topics or scales
  - ☐ Mainly limited range of topics or scales

    Topic areas:

    Typical scales:
    - ☐ 1:50000 and above
    - ☐ 1:50000 - 1:250000
    - ☐ 1:250000 - 1:1M
    - ☐ 1:1M and smaller
- ☐ 2. Map user
  - ☐ Map curator or Librarian
  - ☐ General map
  - ☐ Specialist map user

    Main topic areas:

    Typical scales:
    - ☐ 1:50000 and above
    - ☐ 1:50000 - 1:250000
    - ☐ 1:250000 - 1:1M
    - ☐ 1:1M and smaller

Appendix D: selection index for maps at the same scale.

selection index for maps at 1/250000

sc: 250000												
			250000			500000			1000000		
	map number		LD	LD	LD	LD	LD	LD	LD	LD	LD
FEATURES	sub features	lod	1	5	10	1	5	10	1	5	10
motorways	normal	8	*	*	*	*	*	*		*	*
	under construction	2			*						
	motorway tunnel	2			*						
	full + limited access	2			*						
	motorway junction	6	*	*	*		*	*			*
primary route	primary route	6	*	*	*		*	*			*
	dual carriageway	2			*						
	under construction	2			*						
	single carriageway	2			*						
	tunnel	0									
a roads	main road	6	*	*	*		*	*			*
	dual carriageway	2			*						
	under construction	2			*						
	single carriageway	2			*						
	narrow roads	2			*						
b roads	secondary roads	6	*	*	*		*	*			*
	dual carriageway	2			*						
	narrow road	2			*						
minor road	minor road	2			*						
	under construction road	0									
	other road	6	*	*	*		*	*			*
	unclassified road	2			*						

additional road features	projected by pass roads	2			*								
	all weather road	4		*	*			*					
	dry weather road	4		*	*			*					
	narrow road with passing places	2			*								
	gradients- sleep	4		*	*			*					
	toll	4		*	*			*					
	footpath, trail	4											
	cart track	2			*								
	loose surface	2			*								
	cross road	2			*								
	national road	2			*								
railway	standard	8	*	*	*	*	*	*			*	*	
	narrow	2			*								
	railway tunnel	4		*	*			*					
	single standard	2			*								
	single narrow	2			*								
	double standard	2			*								
	double narrow	2			*								
	multiple standard	2			*								
	multiple narrow	2			*								
	railway station	4		*	*			*					
	tourist railway	2			*								
water feature	stream and wadi	4		*	*			*					
	lake	8	*	*	*	*	*	*			*	*	
	dam	2			*								
	glacier	2			*								
	glacial moraine	2			*								

	spring- well- cistern	2			*								
	cliff-slope	2			*								
	foreshore area	2			*								
	sand dunes	4		*	*			*					
	rock	4		*	*			*					
	mudflat	2			*								
	bridge	2			*								
	tunnel	0											
	canal	4		*	*			*					
	navigable canal	2			*								
	non navigable canal	2			*								
	vehicular ferry	4		*	*			*					
	ferry route link	0											
	passenger ferry	4		*	*			*					
	river/ main	8	*	*	*	*	*	*			*	*	
	2nd river	8	*	*	*	*	*	*			*	*	
	marsh- swamp	4		*	*			*					
settlements	city	10	*	*	*	*	*	*	*	*	*	*	
	town	10	*	*	*	*	*	*	*	*	*	*	
	2nd town	6	*	*	*		*	*				*	
	other town	4		*	*			*					
	village	4		*	*			*					
	small villages	4		*	*			*					
	landmark feature	2			*								
	urban area	6	*	*	*		*	*				*	
boundary	national boundary	8	*	*	*	*	*	*			*	*	
	county boundary	8	*	*	*	*	*	*			*	*	
	state boundary	4		*	*			*					
	district boundary	2			*								

	sub district boundary	0											
	national forest park	2			*								
	coastline	8	*	*	*	*	*	*			*	*	
	national park	4		*	*			*					
land use	wood forest	6	*	*	*		*	*				*	
	orchard	2			*								
	mine	2			*								
	airport	6	*	*	*		*	*				*	
	airfield	4		*	*			*					
	seaplane port	2			*								
	heliport	2			*								
	ruin	2			*								
	lighthouse	4		*	*			*					
	lightship	2			*								
	mound	2			*								
	zone	2			*								
tourist features	castle	4		*	*			*					
	historic house	2			*								
	park- garden	4		*	*			*					
	cathedral	6	*	*	*		*	*				*	
	battle site	4		*	*			*					
	nature reserve	2			*								
	wildlife park	2			*								
	information centre	2			*								
	golf course	2			*								
	youth hostel	2			*								
	motor racing centre	2			*								
	race course	2			*								
	camping- caravanning	2			*								

	cave	2			*				*				
	museum- theatre	2			*								
	nature or forest trail	0											
	skiing	0											
	railway	0											
	zoo	0											
	other tourist feature	4		*	*				*				
	antiquities	2			*								
topographic features	horizonal control	2			*								
	point(spot high)	2			*								
	distance	4		*	*				*				
	submarine contours	2			*								
	contours	4		*	*				*				
	mileage	2			*								
	height	4		*	*				*				
populated places		4		*	*				*				

selection index for maps at 1/500000

sc: 500000									
			500000			1000000		
	map number	lod	LD	LD	LD	LD	LD	LD
FEATURES	sub features		1	5	10	1	5	10
motorways	normal	8	*	*	*	*	*	*
	under construction	4		*	*			*
	motorway tunnel	2			*			
	full + limited access	4		*	*			*
	motorway junction	4		*	*			*
primary route	primary route	6	*	*	*		*	*
	dual carriageway	2			*			
	under construction	2			*			
	single carriageway	2			*			
	tunnel	2			*			
a roads	main road	6	*	*	*		*	*
	dual carriageway	2			*			
	under construction	4		*	*			*
	single carriageway	4		*	*			*
	narrow roads	2			*			
b roads	secondary roads	4		*	*			*
	dual carriageway	2			*			
	narrow road	2			*			
minor road	minor road	2			*			
	under construction road	0						
	other road	4		*	*			*
	unclassified road	4		*	*			*
additional road features	projected by pass roads	2			*			
	all weather road	2			*			
	dry weather road	0						
	narrow road with passing places	0						
	gradients- sleep	4		*	*			*
	toll	4		*	*			*
	footpath, trail	2			*			
	cart track	0						
	loose surface	0						
	cross road	0						
	national road	2			*			
railway	standard	4		*	*			*
	narrow	0						
	railway tunnel	4		*	*			*
	single standard	2			*			
	single narrow	2			*			
	double standard	2			*			
	double narrow	2			*			
	multiple standard	0						
	multiple narrow	0						

	railway station	2					*							
	tourist railway	2					*							
water feature	stream and wadi	2					*							
	lake	8		*		*	*		*		*		*	
	dam	2					*							
	glacier	2					*							
	glacial moraine	2					*							
	spring- well- cistern	0												
	cliff-slope	2					*							
	foreshore area	2					*							
	sand dunes	2					*							
	rock	2					*							
	mudflat	2					*							
	bridge	2					*							
	tunnel	0												
	canal	4				*	*							*
	navigable canal	2					*							
	non navigable canal	2					*							
	vehicular ferry	4				*	*							*
	ferry route link	2					*							
	passenger ferry	2					*							
	river/ main	8		*		*	*		*		*		*	
	2nd river	6		*		*	*				*		*	
	marsh- swamp	2					*							
settlements	city	10		*		*	*		*		*		*	
	town	8		*		*	*		*		*		*	
	2nd town	4				*	*						*	
	other town	2					*							
	village	6		*		*	*				*		*	
	small villages	4				*	*						*	
	landmark feature	2					*							
	urban area	6		*		*	*				*		*	
boundary	national boundary	8		*		*	*		*		*		*	
	county boundary	6		*		*	*				*		*	
	state boundary	4				*	*						*	
	district boundary	2					*							
	sub district boundary	2					*							
	national forest park	4				*	*						*	
	coastline	8		*		*	*		*		*		*	
	national park	2					*							
land use	wood forest	2					*							
	orchard	2					*							
	mine	2					*							
	airport	4				*	*						*	
	airfield	2					*							
	seaplane port	2					*							
	heliport	0												
	ruin	0												
	lighthouse	2					*							
	lightship	2					*							

	mound	2					*						
	zone	0											
tourist features	castle	0											
	historic house	0											
	park- garden	2					*						
	cathedral	2					*						
	battle site	0											
	nature reserve	0											
	wildlife park	0											
	information centre	2					*						
	golf course	0											
	youth hostel	0											
	motor racing centre	0											
	race course	0											
	camping- caravanning	2					*						
	cave	0											
	museum- theatre	0											
	nature or forest trail	0											
	skiing	0											
	railway	0											
	zoo	0											
	other tourist feature	2					*						
	antiquities	0											
topographic features	horizonal control	0											
	point(spot high)	4				*	*						*
	distance	2					*						
	submarine contours	2					*						
	contours	4				*	*						*
	mileage	2					*						
	height	4				*	*						*
populated places		0											
telephone call box		2					*						

selection index for maps at 1/1000000

sc: 1000000					
			1000000		
	map number	lod	LD	LD	LD
FEATURES	sub features		1	5	10
motorways	normal	8	*	*	*
	under construction	2			*
	motorway tunnel	2			*
	full + limited access	0			
	motorway junction	6	*	*	*
primary route	primary route	6	*	*	*
	dual carriageway	2			*
	under construction	2			*
	single carriageway	0			
	tunnel	0			
a roads	main road	6	*	*	*
	dual carriageway	4		*	*
	under construction	2			*
	single carriageway	0			
	narrow roads	2			*
b roads	secondary roads	6	*	*	*
	dual carriageway	2			*
	narrow road	0			
minor road	minor road	2			*
	under construction road	0			
	other road	4		*	*
	unclassified road	0			
additional road features	projected by pass roads	0			
	all weather road	2			*
	dry weather road	0			
	narrow road with passing places	0			
	gradients- sleep	0			
	toll	2			*
	footpath, trail	4		*	*
	cart track	0			
	loose surface	0			
	cross road	0			
	national road	0			
railway	standard	4		*	*
	narrow	4		*	*
	railway tunnel	4		*	*
	single standard	2			*
	single narrow	4		*	*
	double standard	0			
	double narrow	2			*
	multiple standard	4		*	*
	multiple narrow	4		*	*
	railway station	2			*

	tourist railway	0					
water feature	stream and wadi	2					*
	lake	8		*		*	*
	dam	2					*
	glacier	2					*
	glacial moraine	2					*
	spring- well- cistern	2					*
	cliff-slope	4				*	*
	foreshore area	4				*	*
	sand dunes	4				*	*
	rock	2					*
	mudflat	2					*
	bridge	0					
	tunnel	2					*
	canal	4				*	*
	navigable canal	2					*
	non navigable canal	0					
	vehicular ferry	4				*	*
	ferry route link	2					*
	passenger ferry	4				*	*
	river/ main	8		*		*	*
	2nd river	8		*		*	*
	marsh- swamp	6		*		*	*
settlements	city	10		*		*	*
	town	8		*		*	*
	2nd town	6		*		*	*
	other town	6		*		*	*
	village	6		*		*	*
	small villages	4				*	*
	landmark feature	2					*
	urban area	6		*		*	*
boundary	national boundary	8		*		*	*
	county boundary	4				*	*
	state boundary	4				*	*
	district boundary	4				*	*
	sub district boundary	0					
	national forest park	2					*
	coastline	8		*		*	*
	national park	2					*
land use	wood forest	4				*	*
	orchard	2					*
	mine	4				*	*
	airport	4				*	*
	airfield	2					*
	seaplane port	2					*
	heliport	0					
	ruin	4				*	*
	lighthouse	4				*	*
	lightship	0					
	mound	0					

	zone	2					*
tourist features	castle	2					*
	historic house	2					*
	park- garden	2					*
	cathedral	2					*
	battle site	0					
	nature reserve	0					
	wildlife park	2					*
	information centre	2					*
	golf course	0					
	youth hostel	0					
	motor racing centre	0					
	race course	0					
	camping- caravanning	2					*
	cave	2					*
	museum- theatre	2					*
	nature or forest trail	0					
	skiing	2					*
	railway	0					
	zoo	0					
	other tourist feature	2					*
	antiquities	2					*
topographic features	horizonal control	2					*
	point(spot high)	4				*	*
	distance	2					*
	submarine contours	0					
	contours	4				*	*
	mileage	0					
	height	4				*	*
populated places							

Appendix E: selection index for maps at the same topic.

selection index for climate maps

			250000			500000			1000000		
	map number		LD	LD	LD	LD	LD	LD	LD	LD	LD
FEATURES	sub features	lod	1	5	10	1	5	10	1	5	10
motorways	normal	4		*	*			*			
	under construction	0									
	motorway tunnel	0									
	full + limited access	0									
	motorway junction	4		*	*			*			
primary route	primary route	4		*	*			*			
	dual carriageway	0									
	under construction	0									
	single carriageway	0									
	tunnel	0									
a roads	main road	2			*						
	dual carriageway	0									
	under construction	0									
	single carriageway	0									
	narrow roads	0									
b roads	secondary roads	2			*						
	dual carriageway	0									
	narrow road	0									
minor road	minor road	0									
	under construction road	0									
	other road	2			*						
	unclassified road	0									
additional road	projected by	0									

features	pass roads												
	all weather road	0											
	dry weather road	0											
	narrow road with passing places	0											
	gradients- sleep	0											
	toll	0											
	footpath, trail	0											
	cart track	0											
	loose surface	0											
	cross road	0											
	national road	0											
railway	standard	2			*								
	narrow	0											
	railway tunnel	0											
	single standard	0											
	single narrow	0											
	double standard	0											
	double narrow	0											
	multiple standard	0											
	multiple narrow	0											
	railway station	0											
	tourist railway	0											
water feature	stream and wadi	0											
	lake	6	*	*	*		*	*				*	
	dam	0											
	glacier	0											
	glacial moraine	0											
	spring- well- cistern	0											

	cliff-slope	0										
	foreshore area	0										
	sand dunes	0										
	rock	0										
	mudflat	0										
	bridge	0										
	tunnel	0										
	canal	0										
	navigable canal	0										
	non navigable canal	0										
	vehicular ferry	0										
	ferry route link	0										
	passenger ferry	0										
	river/ main	2			*							
	2nd river	2			*							
	marsh- swamp	0										
settlements	city	8	*	*	*	*	*	*		*	*	
	town	8	*	*	*	*	*	*		*	*	
	2nd town	0										
	other town	0										
	village	2			*							
	small villages	0										
	landmark feature	0										
	urban area	4		*	*			*				
boundary	national boundary	4		*	*			*				
	county boundary	4		*	*			*				
	state boundary	6	*	*	*		*	*				*
	district boundary	0										
	sub district boundary	0										

	national forest park	2			*							
	coastline	8	*	*	*	*	*	*		*	*	
	national park	0										
land use	wood forest	0										
	orchard	0										
	mine	0										
	airport	0										
	airfield	0										
	seaplane port	0										
	heliport	0										
	ruin	0										
	lighthouse	0										
	lightship	0										
	mound	0										
	zone	0										
tourist features	castle	0										
	historic house	0										
	park- garden	0										
	cathedral	0										
	battle site	0										
	nature reserve	0										
	wildlife park	0										
	information centre	0										
	golf course	0										
	youth hostel	0										
	motor racing centre	0										
	race course	0										
	camping- caravanning	0										
	cave	0										

	museum- theatre	0													
	nature or forest trail	0													
	skiing	0													
	railway	0													
	zoo	0													
	other tourist feature	0													
	antiquities	0													
topographic features	horizonal control	0													
	point(spot high)	4			*	*				*					
	distance	0													
	submarine contours	0													
	contours	2				*									
	mileage	0													
	height	4			*	*				*					
populated places		0													

selection index for communication maps

			250000			500000			1000000		
	map number		LD	LD	LD	LD	LD	LD	LD	LD	LD
FEATURES	sub features	lod	1	5	10	1	5	10	1	5	10
motorways	normal	8	*	*	*	*	*	*		*	*
	under construction	6	*	*	*		*	*			*
	motorway tunnel	4		*	*			*			
	full + limited access	6	*	*	*		*	*			*
	motorway junction	6	*	*	*		*	*			*
primary route	primary route	6	*	*	*		*	*			*
	dual carriageway	4		*	*			*			
	under construction	4		*	*			*			
	single carriageway	4		*	*			*			
	tunnel	2			*						
a roads	main road	8	*	*	*	*	*	*		*	*
	dual carriageway	4		*	*			*			
	under construction	4		*	*			*			
	single carriageway	4		*	*			*			
	narrow roads	2			*						
b roads	secondary roads	8	*	*	*	*	*	*		*	*
	dual carriageway	4		*	*			*			
	narrow road	2			*						
minor road	minor road	4		*	*			*			
	under construction road	0									
	other road	6	*	*	*		*	*			*
	unclassified road	0									
additional road features	projected by pass roads	4		*	*			*			

	all weather road	2			*							
	dry weather road	0										
	narrow road with passing places	0										
	gradients- sleep	6	*	*	*		*	*				*
	toll	6	*	*	*		*	*				*
	footpath, trail	4		*	*			*				
	cart track	2			*							
	loose surface	0										
	cross road	2			*							
	national road	2			*							
railway	standard	6	*	*	*		*	*				*
	narrow	2			*							
	railway tunnel	4		*	*			*				
	single standard	2			*							
	single narrow	0										
	double standard	2			*							
	double narrow	0										
	multiple standard	0										
	multiple narrow	0										
	railway station	4		*	*			*				
	tourist railway	2			*							
water feature	stream and wadi	2			*							
	lake	8	*	*	*	*	*	*		*		*
	dam	2			*							
	glacier	0										
	glacial moraine	0										
	spring- well- cistern	0										
	cliff-slope	0										
	foreshore area	2			*							

	sand dunes	2			*							
	rock	2			*							
	mudflat	2			*							
	bridge	0										
	tunnel	0										
	canal	6	*	*	*		*	*				*
	navigable canal	2			*							
	non navigable canal	2			*							
	vehicular ferry	6	*	*	*		*	*				*
	ferry route link	2			*							
	passenger ferry	2			*							
	river/ main	10	*	*	*	*	*	*	*	*	*	
	2nd river	6	*	*	*		*	*				*
	marsh- swamp	2			*							
settlements	city	10	*	*	*	*	*	*	*	*	*	
	town	8	*	*	*	*	*	*		*	*	
	2nd town	6	*	*	*		*	*				*
	other town	4		*	*			*				
	village	6	*	*	*		*	*				*
	small villages	4		*	*			*				
	landmark feature	2			*							
	urban area	6	*	*	*		*	*				*
boundary	national boundary	8	*	*	*	*	*	*		*	*	
	county boundary	6	*	*	*		*	*				*
	state boundary	4		*	*			*				
	district boundary	2			*							
	sub district boundary	0										
	national forest park	4		*	*			*				
	coastline	8	*	*	*	*	*	*		*	*	

	national park	4		*	*			*					
land use	wood forest	4		*	*			*					
	orchard	0											
	mine	0											
	airport	8	*	*	*	*	*	*			*	*	
	airfield	4		*	*			*					
	seaplane port	2			*								
	heliport	0											
	ruin	4		*	*			*					
	lighthouse	4		*	*			*					
	lightship	2			*								
	mound	0											
	zone	0											
tourist features	castle	4		*	*			*					
	historic house	2			*								
	park- garden	4		*	*			*					
	cathedral	4		*	*			*					
	battle site	2			*								
	nature reserve	2			*								
	wildlife park	2			*								
	information centre	2			*								
	golf course	2			*								
	youth hostel	2			*								
	motor racing centre	0											
	race course	2			*								
	camping- caravanning	4		*	*			*					
	cave	4		*	*			*					
	museum- theatre	4		*	*			*					
	nature or forest trail	0											
	skiing	0											

	railway	0											
	zoo	0											
	other tourist feature	4		*	*				*				
	antiquities	2			*								
topographic features	horizonal control	2			*								
	point(spot high)	4		*	*				*				
	distance	4		*	*				*				
	submarine contours	2			*								
	contours	2			*								
	mileage	2			*								
	height	6	*	*	*			*	*				*
populated places		4		*	*				*				

selection index for environmental maps

			250000			500000			1000000		
	map number		LD	LD	LD	LD	LD	LD	LD	LD	LD
FEATURES	sub features	lod	1	5	10	1	5	10	1	5	10
motorways	normal	4		*	*			*			
	under construction	0									
	motorway tunnel	0									
	full + limited access	0									
	motorway junction	4		*	*			*			
primary route	primary route	2			*						
	dual carriageway	0									
	under construction	0									
	single carriageway	0									
	tunnel	0									
a roads	main road	2			*						
	dual carriageway	0									
	under construction	0									
	single carriageway	0									
	narrow roads	0									
b roads	secondary roads	2			*						
	dual carriageway	0									
	narrow road	0									
minor road	minor road	0									
	under construction road	0									
	other road	2			*						
	unclassified road	0									
additional road features	projected by	0									
	pass roads	0									

	all weather road	0											
	dry weather road	0											
	narrow road with passing places	0											
	gradients- sleep	0											
	toll	2			*								
	footpath, trail	2			*								
	cart track	0											
	loose surface	0											
	cross road	0											
	national road	0											
railway	standard	4		*	*				*				
	narrow	0											
	railway tunnel	2			*								
	single standard	0											
	single narrow	0											
	double standard	0											
	double narrow	0											
	multiple standard	0											
	multiple narrow	0											
	railway station	2			*								
	tourist railway	0											
water feature	stream and wadi	2			*								
	lake	6	*	*	*			*	*				*
	dam	0											
	glacier	2			*								
	glacial moraine	2			*								
	spring- well- cistern	2			*								
	cliff-slope	2			*								
	foreshore area	0											

	sand dunes	4		*	*			*				
	rock	2			*							
	mudflat	2			*							
	bridge	0										
	tunnel	0										
	canal	4		*	*			*				
	navigable canal	0										
	non navigable canal	0										
	vehicular ferry	2			*							
	ferry route link	0										
	passenger ferry	0										
	river/ main	8	*	*	*	*	*	*		*	*	
	2nd river	6	*	*	*		*	*			*	
	marsh- swamp	2			*							
settlements	city	6	*	*	*		*	*			*	
	town	6	*	*	*		*	*			*	
	2nd town	2			*							
	other town	2			*							
	village	2			*							
	small villages	0										
	landmark feature	0										
	urban area	4		*	*			*				
boundary	national boundary	6	*	*	*		*	*			*	
	county boundary	4		*	*			*				
	state boundary	2			*							
	district boundary	0										
	sub district boundary	0										
	national forest park	0										
	coastline	8	*	*	*	*	*	*		*	*	

	national park	0											
land use	wood forest	2			*								
	orchard	0											
	mine	2			*								
	airport	2			*								
	airfield	0											
	seaplane port	0											
	heliport	0											
	ruin	0											
	lighthouse	0											
	lightship	0											
	mound	0											
	zone	2			*								
tourist features	castle	0											
	historic house	0											
	park- garden	2			*								
	cathedral	2			*								
	battle site	2			*								
	nature reserve	0											
	wildlife park	0											
	information centre	0											
	golf course	0											
	youth hostel	0											
	motor racing centre	0											
	race course	0											
	camping- caravanning	0											
	cave	0											
	museum- theatre	0											
	nature or forest trail	0											
	skiing	0											

	railway	0											
	zoo	0											
	other tourist feature	0											
	antiquities	0											
topographic features	horizonal control	2				*							
	point(spot high)	2				*							
	distance	0											
	submarine contours	0											
	contours	4			*	*				*			
	mileage	0											
	height	2				*							
populated places		0											

selection index for land cover maps

			250000			500000			1000000		
	map number		LD	LD	LD	LD	LD	LD	LD	LD	LD
FEATURES	sub features	lod	1	5	10	1	5	10	1	5	10
motorways	normal	6	*	*	*		*	*			*
	under construction	0									
	motorway tunnel	0									
	full + limited access	0									
	motorway junction	6	*	*	*		*	*			*
primary route	primary route	6	*	*	*		*	*			*
	dual carriageway	0									
	under construction	0									
	single carriageway	0									
	tunnel	0									
a roads	main road	0									
	dual carriageway	0									
	under construction	0									
	single carriageway	0									
	narrow roads	0									
b roads	secondary roads	0									
	dual carriageway	0									
	narrow road	0									
minor road	minor road	0									
	under construction road	0									
	other road	2			*						
	unclassified road	0									
additional road features	projected by pass roads	0									

	all weather road	0																
	dry weather road	0																
	narrow road with passing places	0																
	gradients- sleep	0																
	toll	0																
	footpath, trail	0																
	cart track	0																
	loose surface	0																
	cross road	0																
	national road	0																
railway	standard	2					*											
	narrow	0																
	railway tunnel	2					*											
	single standard	0																
	single narrow	0																
	double standard	0																
	double narrow	0																
	multiple standard	0																
	multiple narrow	0																
	railway station	0																
	tourist railway	0																
water feature	stream and wadi	0																
	lake	8		*		*	*		*		*					*		*
	dam	2					*											
	glacier	0																
	glacial moraine	0																
	spring- well- cistern	0																
	cliff-slope	0																
	foreshore area	2					*											

	sand dunes	2				*										
	rock	2				*										
	mudflat	0														
	bridge	0														
	tunnel	0														
	canal	0														
	navigable canal	2				*										
	non navigable canal	0														
	vehicular ferry	2				*										
	ferry route link	0														
	passenger ferry	2				*										
	river/ main	8		*		*		*		*				*		*
	2nd river	8		*		*		*		*				*		*
	marsh- swamp	2				*										
settlements	city	8		*		*		*		*		*				*
	town	6		*		*				*		*				*
	2nd town	2				*										
	other town	2				*										
	village	2				*										
	small villages	2				*										
	landmark feature	0														
	urban area	6		*		*		*		*						*
boundary	national boundary	6		*		*		*				*		*		*
	county boundary	2				*										
	state boundary	2				*										
	district boundary	0														
	sub district boundary	0														
	national forest park	2				*										
	coastline	8		*		*		*		*		*				*

	national park	2					*												
land use	wood forest	4				*	*						*						
	orchard	0																	
	mine	0																	
	airport	2					*												
	airfield	2					*												
	seaplane port	2					*												
	heliport	0																	
	ruin	0																	
	lighthouse	2					*												
	lightship	0																	
	mound	0																	
	zone	0																	
tourist features	castle	0																	
	historic house	0																	
	park- garden	0																	
	cathedral	0																	
	battle site	0																	
	nature reserve	0																	
	wildlife park	0																	
	information centre	0																	
	golf course	0																	
	youth hostel	0																	
	motor racing centre	0																	
	race course	0																	
	camping- caravanning	0																	
	cave	0																	
	museum- theatre	0																	
	nature or forest trail	0																	
	skiing	0																	

	railway	0																	
	zoo	0																	
	other tourist feature	0																	
	antiquities	0																	
topographic features	horizonal control	2					*												
	point(spot high)	0																	
	distance	0																	
	submarine contours	0																	
	contours	2					*												
	mileage	0																	
	height	2					*												
populated places																			

selection index for land use maps

			250000			500000			1000000		
	map number		LD	LD	LD	LD	LD	LD	LD	LD	LD
FEATURES	sub features	lod	1	5	10	1	5	10	1	5	10
motorways	normal	6	*	*	*		*	*			*
	under construction	0									
	motorway tunnel	0									
	full + limited access	0									
	motorway junction	4		*	*			*			
primary route	primary route	4		*	*			*			
	dual carriageway	0									
	under construction	0									
	single carriageway	0									
	tunnel	0									
a roads	main road	2			*						
	dual carriageway	0									
	under construction	0									
	single carriageway	0									
	narrow roads	0									
b roads	secondary roads	2			*						
	dual carriageway	0									
	narrow road	0									
minor road	minor road	0									
	under construction road	0									
	other road	0									
	unclassified road	0									
additional road	projected by	0									

features	pass roads											
	all weather road	0										
	dry weather road	0										
	narrow road with passing places	0										
	gradients- sleep	0										
	toll	0										
	footpath, trail	0										
	cart track	0										
	loose surface	0										
	cross road	0										
	national road	0										
railway	standard	2			*							
	narrow	0										
	railway tunnel	0										
	single standard	0										
	single narrow	0										
	double standard	0										
	double narrow	0										
	multiple standard	0										
	multiple narrow	0										
	railway station	0										
	tourist railway	0										
water feature	stream and wadi	0										
	lake	8	*	*	*	*	*	*		*	*	
	dam	0										
	glacier	0										
	glacial moraine	0										
	spring- well- cistern	0										
	cliff-slope	0										

	foreshore area	0										
	sand dunes	0										
	rock	0										
	mudflat	0										
	bridge	0										
	tunnel	0										
	canal	2			*							
	navigable canal	0										
	non navigable canal	0										
	vehicular ferry	0										
	ferry route link	0										
	passenger ferry	0										
	river/ main	8	*	*	*	*	*	*		*	*	
	2nd river	6	*	*	*		*	*			*	
	marsh- swamp	2			*							
settlements	city	10	*	*	*	*	*	*	*	*	*	
	town	4		*	*			*				
	2nd town	0										
	other town	0										
	village	0										
	small villages	0										
	landmark feature	0										
	urban area	8	*	*	*	*	*	*		*	*	
boundary	national boundary	4		*	*			*				
	county boundary	2			*							
	state boundary	2			*							
	district boundary	0										
	sub district boundary	0										
	national forest park	0										
	coastline	6	*	*	*		*	*			*	

	national park	2			*							
land use	wood forest	6	*	*	*		*	*				*
	orchard	4		*	*			*				
	mine	0										
	airport	2			*							
	airfield	0										
	seaplane port	0										
	heliport	2			*							
	ruin	0										
	lighthouse	0										
	lightship	0										
	mound	0										
	zone	0										
tourist features	castle	2			*							
	historic house	0										
	park- garden	2			*							
	cathedral	2			*							
	battle site	0										
	nature reserve	0										
	wildlife park	0										
	information centre	2			*							
	golf course	0										
	youth hostel	0										
	motor racing centre	0										
	race course	0										
	camping- caravanning	0										
	cave	0										
	museum- theatre	0										
	nature or forest trail	0										
	skiing	0										

	railway	0											
	zoo	0											
	other tourist feature	2			*								
	antiquities	0											
topographic features	horizonal control	0											
	point(spot high)	0											
	distance	0											
	submarine contours	0											
	contours	0											
	mileage	0											
	height	0											
populated places		0											

selection index for political maps

			250000			500000			1000000		
	map number		LD	LD	LD	LD	LD	LD	LD	LD	LD
FEATURES	sub features	lod	1	5	10	1	5	10	1	5	10
motorways	normal	6	*	*	*		*	*			*
	under construction	0									
	motorway tunnel	0									
	full + limited access	0									
	motorway junction	6	*	*	*		*	*			*
primary route	primary route	6	*	*	*		*	*			*
	dual carriageway	0									
	under construction	0									
	single carriageway	0									
	tunnel	0									
a roads	main road	2			*						
	dual carriageway	2			*						
	under construction	0									
	single carriageway	0									
	narrow roads	0									
b roads	secondary roads	2			*						
	dual carriageway	0									
	narrow road	0									
minor road	minor road	2			*						
	under construction road	0									
	other road	2			*						
	unclassified road	0									
additional road features	projected by pass roads	0									

	all weather road	0										
	dry weather road	0										
	narrow road with passing places	0										
	gradients- sleep	0										
	toll	0										
	footpath, trail	0										
	cart track	0										
	loose surface	0										
	cross road	0										
	national road	0										
railway	standard	6	*	*	*		*	*			*	
	narrow	0										
	railway tunnel	2			*							
	single standard	0										
	single narrow	0										
	double standard	0										
	double narrow	0										
	multiple standard	0										
	multiple narrow	0										
	railway station	2			*							
	tourist railway	0										
water feature	stream and wadi	0										
	lake	6	*	*	*		*	*			*	
	dam	0										
	glacier	0										
	glacial moraine	0										
	spring- well- cistern	0										
	cliff-slope	0										
	foreshore area	0										

	sand dunes	0										
	rock	0										
	mudflat	0										
	bridge	0										
	tunnel	0										
	canal	2			*							
	navigable canal	0										
	non navigable canal	0										
	vehicular ferry	2			*							
	ferry route link	0										
	passenger ferry	2			*							
	river/ main	6	*	*	*		*	*				*
	2nd river	4		*	*			*				
	marsh- swamp	0										
settlements	city	8	*	*	*	*	*	*			*	*
	town	8	*	*	*	*	*	*			*	*
	2nd town	6	*	*	*		*	*				*
	other town	2			*							
	village	6	*	*	*		*	*				*
	small villages	4		*	*			*				
	landmark feature	0										
	urban area	6	*	*	*		*	*				*
boundary	national boundary	8	*	*	*	*	*	*			*	*
	county boundary	8	*	*	*	*	*	*			*	*
	state boundary	6	*	*	*		*	*				*
	district boundary	6	*	*	*		*	*				*
	sub district boundary	4		*	*			*				
	national forest park	0										
	coastline	6	*	*	*		*	*				*

	national park	2			*								
land use	wood forest	2			*								
	orchard	0											
	mine	2			*								
	airport	4		*	*				*				
	airfield	0											
	seaplane port	0											
	heliport	0											
	ruin	0											
	lighthouse	0											
	lightship	0											
	mound	0											
	zone	0											
tourist features	castle	0											
	historic house	0											
	park- garden	2			*								
	cathedral	0											
	battle site	0											
	nature reserve	0											
	wildlife park	0											
	information centre	0											
	golf course	0											
	youth hostel	0											
	motor racing centre	0											
	race course	0											
	camping- caravanning	0											
	cave	0											
	museum- theatre	0											
	nature or forest trail	0											
	skiing	0											

	railway	0											
	zoo	0											
	other tourist feature	0											
	antiquities	0											
topographic features	horizonal control	0											
	point(spot high)	2			*								
	distance	0											
	submarine contours	0											
	contours	4		*	*				*				
	mileage	0											
	height	2			*								
populated places		0											

selection index for population maps

			250000			500000			1000000		
	map number		LD	LD	LD	LD	LD	LD	LD	LD	LD
FEATURES	sub features	lod	1	5	10	1	5	10	1	5	10
motorways	normal	2			*						
	under construction	0									
	motorway tunnel	0									
	full + limited access	0									
	motorway junction	0									
primary route	primary route	2			*						
	dual carriageway	0									
	under construction	0									
	single carriageway	0									
	tunnel	0									
a roads	main road	0									
	dual carriageway	0									
	under construction	0									
	single carriageway	0									
	narrow roads	0									
b roads	secondary roads	0									
	dual carriageway	0									
	narrow road	0									
minor road	minor road	0									
	under construction road	0									
	other road	0									
	unclassified road	0									
additional road features	projected by	0									
	pass roads	0									

	all weather road	0										
	dry weather road	0										
	narrow road with passing places	0 0										
	gradients- sleep	0										
	toll	0										
	footpath, trail	0										
	cart track	0										
	loose surface	0										
	cross road	0										
	national road	0										
railway	standard	0										
	narrow	0										
	railway tunnel	0										
	single standard	0										
	single narrow	0										
	double standard	0										
	double narrow	0										
	multiple standard	0										
	multiple narrow	0										
	railway station	0										
	tourist railway	0										
water feature	stream and wadi	0										
	lake	8	*	*	*	*	*	*		*	*	
	dam	0										
	glacier	0										
	glacial moraine	0										
	spring- well- cistern	0										
	cliff-slope	0										

	foreshore area	0										
	sand dunes	0										
	rock	2			*							
	mudflat	0										
	bridge	0										
	tunnel	0										
	canal	0										
	navigable canal	0										
	non navigable canal	0										
	vehicular ferry	0										
	ferry route link	0										
	passenger ferry	0										
	river/ main	10	*	*	*	*	*	*	*	*	*	
	2nd river	8	*	*	*	*	*	*		*	*	
	marsh- swamp	2			*							
settlements	city	10	*	*	*	*	*	*	*	*	*	
	town	10	*	*	*	*	*	*	*	*	*	
	2nd town	10	*	*	*	*	*	*	*	*	*	
	other town	6	*	*	*		*	*			*	
	village	10	*	*	*	*	*	*	*	*	*	
	small villages	8	*	*	*	*	*	*		*	*	
	landmark feature	0										
	urban area	6	*	*	*		*	*			*	
boundary	national boundary	6	*	*	*		*	*			*	
	county boundary	4		*	*			*				
	state boundary	4		*	*			*				
	district boundary	0										
	sub district boundary	0										
	national forest park	0										
	coastline	10	*	*	*	*	*	*	*	*	*	

	national park	0											
land use	wood forest	2			*								
	orchard	0											
	mine	0											
	airport	0											
	airfield	0											
	seaplane port	0											
	heliport	0											
	ruin	0											
	lighthouse	0											
	lightship	0											
	mound	0											
	zone	0											
tourist features	castle	0											
	historic house	0											
	park- garden	0											
	cathedral	0											
	battle site	0											
	nature reserve	0											
	wildlife park	0											
	information centre	0											
	golf course	0											
	youth hostel	0											
	motor racing centre	0											
	race course	0											
	camping- caravanning	0											
	cave	0											
	museum- theatre	0											
	nature or forest trail	0											
	skiing	0											

	railway	0											
	zoo	0											
	other tourist feature	0											
	antiquities	0											
topographic features	horizonal control	0											
	point(spot high)	2			*								
	distance	0											
	submarine contours	0											
	contours	0											
	mileage	0											
	height	0											
populated places		0											

selection index for relief maps

			250000			500000			1000000		
	map number		LD	LD	LD	LD	LD	LD	LD	LD	LD
FEATURES	sub features	lod	1	5	10	1	5	10	1	5	10
motorways	normal	4		*	*			*			
	under construction	0									
	motorway tunnel	0									
	full + limited access	0									
	motorway junction	4		*	*			*			
primary route	primary route	4		*	*			*			
	dual carriageway	0									
	under construction	0									
	single carriageway	0									
	tunnel	0									
a roads	main road	2			*						
	dual carriageway	0									
	under construction	0									
	single carriageway	0									
	narrow roads	0									
b roads	secondary roads	2			*						
	dual carriageway	0									
	narrow road	0									
minor road	minor road	0									
	under construction road	0									
	other road	2			*						
	unclassified road	0									
additional road features	projected by pass roads	0									
	all weather road	0									

	dry weather road	0											
	narrow road with passing places	0											
	gradients- sleep	0											
	toll	0											
	footpath, trail	0											
	cart track	0											
	loose surface	0											
	cross road	0											
	national road	0											
railway	standard	2			*								
	narrow	0											
	railway tunnel	0											
	single standard	0											
	single narrow	0											
	double standard	0											
	double narrow	0											
	multiple standard	0											
	multiple narrow	0											
	railway station	0											
	tourist railway	0											
water feature	stream and wadi	0											
	lake	10	*	*	*	*	*	*	*	*	*		
	dam	0											
	glacier	2			*								
	glacial moraine	0											
	spring- well- cistern	0											
	cliff-slope	2			*								
	foreshore area	2			*								

	sand dunes	0											
	rock	0											
	mudflat	0											
	bridge	0											
	tunnel	2			*								
	canal	4		*	*				*				
	navigable canal	2			*								
	non navigable canal	2			*								
	vehicular ferry	0											
	ferry route link	0											
	passenger ferry	0											
	river/ main	10	*	*	*	*	*	*	*	*	*		
	2nd river	8	*	*	*	*	*	*		*	*		
	marsh- swamp	2			*								
settlements	city	8	*	*	*	*	*	*		*	*		
	town	6	*	*	*		*	*			*		
	2nd town	2			*								
	other town	0											
	village	4		*	*			*					
	small villages	2			*								
	landmark feature	0											
	urban area	6	*	*	*		*	*			*		
boundary	national boundary	4		*	*			*					
	county boundary	2			*								
	state boundary	2			*								
	district boundary	2			*								
	sub district boundary	0											
	national forest park	2			*								
	coastline	6	*	*	*		*	*			*		

| | | |

	skiing	0																
	railway	0																
	zoo	0																
	other tourist feature	2				*												
	antiquities	0																
topographic features	horizonal control	0																
	point(spot high)	2				*												
	distance	2				*												
	submarine contours	0																
	contours	0																
	mileage	0																
	height	2				*												
populated places		0																

selection index for topographic maps

			250000			500000			1000000		
	map number		LD	LD	LD	LD	LD	LD	LD	LD	LD
FEATURES	sub features	lod	1	5	10	1	5	10	1	5	10
motorways	normal	6	*	*	*		*	*			*
	under construction	2			*						
	motorway tunnel	0									
	full + limited access	2			*						
	motorway junction	4		*	*			*			
primary route	primary route	6	*	*	*		*	*			*
	dual carriageway	2			*						
	under construction	2			*						
	single carriageway	0									
	tunnel	0									
a roads	main road	6	*	*	*		*	*			*
	dual carriageway	2			*						
	under construction	2			*						
	single carriageway	2			*						
	narrow roads	0									
b roads	secondary roads	6	*	*	*		*	*			*
	dual carriageway	2			*						
	narrow road	2			*						
minor road	minor road	2			*						
	under construction road	0									
	other road	6	*	*	*		*	*			*
	unclassified road	0									
additional road features	projected by pass roads	2			*						

	all weather road	4		*	*			*					
	dry weather road	2			*								
	narrow road with passing places	2			*								
	gradients- sleep	2			*								
	toll	2			*								
	footpath, trail	6	*	*	*			*	*				*
	cart track	2			*								
	loose surface	2			*								
	cross road	2			*								
	national road	0											
railway	standard	6	*	*	*			*	*				*
	narrow	4		*	*				*				
	railway tunnel	4		*	*				*				
	single standard	4		*	*				*				
	single narrow	4		*	*				*				
	double standard	2			*								
	double narrow	2			*								
	multiple standard	4		*	*				*				
	multiple narrow	4		*	*				*				
	railway station	4		*	*				*				
	tourist railway	2			*								
water feature	stream and wadi	4		*	*				*				
	lake	6	*	*	*			*	*				*
	dam	2			*								
	glacier	2			*								
	glacial moraine	2			*								
	spring- well- cistern	2			*								
	cliff-slope	4		*	*				*				
	foreshore area	2			*								

	sand dunes	4		*	*			*				
	rock	2			*							
	mudflat	2			*							
	bridge	2			*							
	tunnel	0										
	canal	4		*	*			*				
	navigable canal	2			*							
	non navigable canal	2			*							
	vehicular ferry	4		*	*			*				
	ferry route link	0										
	passenger ferry	4		*	*			*				
	river/ main	8	*	*	*	*	*	*		*	*	
	2nd river	6	*	*	*		*	*			*	
	marsh- swamp	6	*	*	*		*	*			*	
settlements	city	8	*	*	*	*	*	*		*	*	
	town	8	*	*	*	*	*	*		*	*	
	2nd town	6	*	*	*		*	*			*	
	other town	6	*	*	*		*	*			*	
	village	6	*	*	*		*	*			*	
	small villages	4		*	*			*				
	landmark feature	2			*							
	urban area	6	*	*	*		*	*			*	
boundary	national boundary	6	*	*	*		*	*			*	
	county boundary	6	*	*	*		*	*			*	
	state boundary	4		*	*			*				
	district boundary	2			*							
	sub district boundary	0										
	national forest park	2			*							
	coastline	4		*	*			*				
	national park	4		*	*			*				

land use	wood forest	4		*	*			*					
	orchard	2			*								
	mine	4		*	*			*					
	airport	6	*	*	*		*	*					*
	airfield	4		*	*			*					
	seaplane port	4		*	*			*					
	heliport	2			*								
	ruin	4		*	*			*					
	lighthouse	4		*	*			*					
	lightship	2			*								
	mound	2			*								
	zone	2			*								
tourist features	castle	2			*								
	historic house	2			*								
	park- garden	2			*								
	cathedral	4		*	*			*					
	battle site	2			*								
	nature reserve	2			*								
	wildlife park	2			*								
	information centre	2			*								
	golf course	2			*								
	youth hostel	2			*								
	motor racing centre	2			*								
	race course	2			*								
	camping- caravanning	2			*								
	cave	0											
	museum- theatre	2			*								
	nature or forest trail	0											
	skiing	2			*								
	railway	0											

	zoo	0										
	other tourist feature	2			*							
	antiquities	2			*							
topographic features	horizonal control	2			*							
	point(spot high)	6	*	*	*		*	*				*
	distance	4		*	*			*				
	submarine contours	2			*							
	contours	6	*	*	*		*	*				*
	mileage	0										
	height	4		*	*			*				
populated places		2			*							

Appendix F :

questionnaire result for different map topics.

questionnaire										
Evaluation										
FEATURES	Sub features	Topographic	Political	Population	Land use	Relief	Land cover	climate	communication	environmental science
Limited access highways (motorways)	carriagways	E: 86% D: 0% Q: 0% U: 14%	E: 43% D: 43% Q: 0% U: 14%	E: 14% D: 43% Q: 0% U: 43%	E: 43% D: 43% Q: 14% U: 0%	E: 14.25% D: 14.25% Q: 28.57% U: 42.85%	E: 43% D:43% Q:14% U: 0%	E: 14% D :0% Q: 29% U: 57%	E: 100% D: 0% Q: 0% U: 0%	E: 29% D: 57% Q: 14% U: 0%
	Junction/ slip road detail	E: 29% D: 14% Q: 29% U: 29%	E: 14% D: 14% Q: 14% U: 57%	E: 14% D: 0% Q: 29% U: 57%	E: 14% D: 0% Q: 43% U: 43%	E: 14% D: 0% Q: 14% U: 71%	E: 14% D: 0% Q: 29% U: 57%	E: 14% D: 0% Q: 14% U: 71%	E: 0% D: 14% Q: 29% U: 57%	E: 14% D: 0% Q: 29% U: 57%
Major road	Key primary routes	E: 86% D: 0% Q: 0% U: 14%	E: 29% D: 57% Q: 0% U: 14%	E: 14% D: 29% Q: 14% U: 43%	E: 29% D: 43% Q: 29% U: 0%	E: 14% D: 14% Q: 29% U: 43%	E: 43% D: 29% Q: 29% U: 0%	E: 14% D: 0% Q: 29% U: 57%	E: 100% D: 0% Q: 0% U: 0%	E: 14% D: 57% Q: 14% U: 14%

	All dual and single carriageway	E: 57% D: 14% Q: 0% U: 29%	E: 14% D: 14% Q: 43% U: 29%	E: 14% D: 0 % Q: 29% U: 57%	E: 29% D: 14% Q: 57% U: 0%	E: 14% D: 0% Q: 29% U: 57%	E: 29% D: 14% Q: 29% U: 29%	E: 14% D: 0% Q: 14% U: 71%	E: 86% D: 0% Q: 14% U: 0%	E: 14% D: 29% Q: 43% U: 14%
Secondary road	Secondary roads	E: 57% D: 29% Q: 0% U: 14%	E: 14% D: 14% Q: 29% U: 43%	E: 14% D: 0% Q: 29% U: 57%	E: 29% D: 14% Q: 43% U: 14%	E: 14% D: 0% Q: 29% U: 57%	E: 29% D: 14% Q: 43% U: 14%	E: 14% D: 0% Q: 14% U: 71%	E: 71% D: 14% Q: 14% U: 0%	E: 14% D: 29% Q: 29% U: 29%
minor road	Other road (surfaced)	E: 43% D: 29% Q: 14% U: 14%	E: 14% D: 14% Q: 29% U: 43%	E: 14% D: 0% Q: 14% U: 71%	E: 14% D: 14% Q: 29% U: 43%	E: 0% D: 14% Q: 29% U: 57%	E: 14% D: 0% Q: 29% U: 57%	E: 0% D: 0% Q: 29% U: 71%	E: 43% D: 29% Q: 29% U: 0%	E: 14% D: 0% Q: 29% U: 57%
	Unclassified road or track	E: 14% D: 29% Q: 43% U: 14%	E: 14% D: 0% Q: 43% U: 43%	E: 14% D: 0% Q: 14% U: 71%	E: 14% D: 0% Q: 29% U: 57%	E: 0% D: 14% Q: 29% U: 57%	E: 14% D: 0% Q: 29% U: 57%	E: 0% D: 0% Q: 29% U: 71%	E: 29% D: 43% Q: 29% U: 0%	E: 14% D: 0% Q: 29% U: 57%
Additional road	Gradients- steep	E: 14% D: 29% Q: 43% U: 14%	E: 0% D: 0% Q: 14% U: 86%	E: 0% D:0% Q:0% U:100%	E: 14% D:14% Q:29% U:43%	E: 14% D:29% Q:14% U:43%	E: 14% D:14% Q:0% U:71%	E: 0% D:0% Q:29% U:71%	E: 29% D: 43% Q: 14% U: 14%	E: 14% D: 14% Q: 29% U: 43%
Features	Toll	E: 14% D:29% Q:14% U:43%	E: 0% D:0% Q:14% U:86%	E: 0% D:0% Q:0% U:100%	E: 14% D:0% Q:14% U:71%	E:0% D:0% Q:14% U:86%	E: 14% D:0% Q:0% U:86%	E: 0% D:0% Q:14% U:86%	E: 43% D: 29% Q: 14% U: 14%	E: 14% D:0% Q:14% U: 71%

	Footpath, trail	E: 41% D: 57% Q: 0% U: 29%	E: 0% D: 14% Q: 29% U: 57%	E: 0% D: 14% Q: 0% U: 86%	E: 14% D: 0% Q: 29% U: 57%	E: 0% D: 0% Q: 43% U: 57%	E: 14% D: 0% Q: 14% U: 71%	E: 0% D: 0% Q: 14% U: 86%	E: 29% D: 43% Q: 29% U: 0%	E: 14% D: 0% Q: 43% U: 43%
Water feature	Major lake	E: 100% D: 0% Q: 0% U: 0%	E: 57% D: 43% Q: 0% U: 0%	E: 43% D: 43% Q: 0% U: 14%	E: 100% D: 0% Q: 0% U: 0%	E: 86% D: 14% Q: 0% U: 0%	E: 100% D: 0% Q: 0% U: 0%	E: 71% D: 29% Q: 0% U: 0%	E: 100% D: 0% Q: 0% U: 0%	E: 100% D: 0% Q: 0% U: 0%
	minor lake	E: 71% D: 29% Q: 0% U: 0%	E: 14% D: 14% Q: 43% U: 29%	E: 14% D: 14% Q: 43% U: 29%	E: 43% D: 43% Q: 14% U: 0%	E: 43% D: 14% Q: 43% U: 0%	E: 71% D: 29% Q: 0% U: 0%	E: 14% D: 14% Q: 29% U: 43%	E: 43% D: 29% Q: 29% U: 0%	E: 29% D: 71% Q: 0% U: 0%
	canal	E: 71% D: 29% Q: 0% U: 0%	E: 14% D: 29% Q: 29% U: 29%	E: 14% D: 29% Q: 29% U: 29%	E: 43% D: 57% Q: 0% U: 0%	E: 29% D:43% Q: 29% U: 0%	E: 43% D: 57% Q: 0% U: 0%	E: 14% D: 14% Q: 29% U: 43%	E: 57% D:29% Q:14% U: 0%	E: 14% D:86% Q:0% U:0%
	Major river	E: 100% D: 0% Q: 0% U: 0%	E: 29% D: 57% Q: 0% U: 14%	E: 29% D: 57% Q: 0% U: 14%	E: 86% D: 14% Q: 0% U: 0%	E: 71% D: 29% Q: 0% U: 0%	E: 86% D: 14% Q: 0% U: 0%	E: 43% D: 29% Q: 14% U: 14%	E: 86% D: 14% Q: 0% U: 0%	E: 100% D: 0% Q: 0% U: 0%
	2nd class river	E: 71% D: 29% Q: 0% U: 0%	E: 0% D: 0% Q: 57% U: 43%	E: 0% D: 0% Q: 43% U: 57%	E: 57% D: 43% Q: 0% U: 0%	E: 71% D: 29% Q: 0% U: 0%	E: 57% D: 43% Q: 0% U: 0%	E: 14% D: 14% Q: 29% U: 43%	E: 57% D: 29% Q: 14% U: 0%	E: 57% D: 43% Q: 0% U: 0%
	3rd class river	E: 29% D: 43% Q: 29% U: 0%	E: 0% D: 0% Q: 29% U: 71%	E: 0% D: 0% Q: 14% U: 86%	E: 14% D: 14% Q: 43% U: 29%	E: 43% D: 29% Q: 29% U: 0%	E: 14% D: 57% Q: 14% U: 14%	E: 14% D: 0% Q: 29% U: 57%	E: 29% D: 29% Q: 29% U: 14%	E: 14% D: 57% Q: 29% U: 0%

	Large area of marsh or swamp	E: 86% D: 14% Q: 0% U: 0%	E: 0% D: 14% Q: 14% U: 71%	E: 0% D: 29% Q: 0% U: 71%	E: 71% D: 29% Q: 0% U: 0%	E: 43% D: 57% Q: 0% U: 0%	E: 86% D: 14% Q: 0% U: 0%	E: 14% D: 43% Q: 29% U: 14%	E: 43% D: 43% Q: 14% U: 0%	E: 71% D: 29% Q: 0% U: 0%
Settlements	City	E: 86% D: 14% Q: 0% U: 0%	E: 86% D: 14% Q: 0% U: 0%	E: 86% D: 14% Q: 0% U: 0%	E: 100% D: 0% Q: 0% U: 0%	E: 71% D: 0% Q: 0% U: 29%	E: 86% D: 0% Q: 14% U: 0%	E: 71% D: 14% Q: 0% U: 14%	E: 100% D: 0% Q: 0% U: 0%	E: 71% D: 29% Q: 0% U: 0%
	town	E: 57% D: 29% Q: 14% U: 0%	E: 29% D: 0% Q: 14% U: 0%	E: 57% D: 43% Q: 0% U: 0%	E: 86% D: 14% Q: 0% U: 0%	E: 29% D: 14% Q: 29% U: 29%	E: 43% D: 43% Q: 14% U: 0%	E: 29% D: 14% Q: 29% U: 29%	E: 71% D: 14% Q: 14% U: 0%	E: 29% D: 57% Q: 14% U: 0%
	village	E: 43% D: 43% Q: 14% U: 0%	E: 14% D: 14% Q: 29% U: 43%	E: 29% D: 43% Q: 29% U: 0%	E: 14% D: 57% Q: 29% U: 0%	E: 14% D: 0% Q: 29% U: 57%	E: 14% D: 14% Q: 43% U: 29%	E: 14% D: 0% Q: 0% U: 86%	E: 29% D: 43% Q: 29% U: 0%	E: 14% D: 29% Q: 57% U: 0%
	Isolated group of buildings	E: 14% D: 43% Q: 0% U: 43%	E: 14% D: 0% Q: 14% U: 71%	E: 29% D: 0% Q: 29% U: 43%	E: 14% D: 14% Q: 29% U: 43%	E: 0% D: 0% Q: 14% U: 86%	E: 14% D: 0% Q: 14% U: 71%	E: 0% D:0% Q:14% U:86%	E: 14% D: 43% Q: 29% U: 14%	E: 14% D: 0% Q: 29% U: 57%
Boundary	National boundary	E: 86% D: 14% Q: 0% U: 0%	E: 100% D: 0% Q: 0% U: 0%	E: 100% D:0% Q:0% U:0%	E: 86% D: 0% Q: 14% U: 0%	E: 43% D: 29% Q: 29% U: 0%	E: 71% D: 14% Q: 14% U: 0%	E: 57% D:14% Q:14% U:14%	E: 100% D: 0% Q: 0% U: 0%	E: 71% D: 14% Q: 14% U: 0%

	First level internal boundary	E: 57% D: 43% Q: 0% U: 0%	E: 86% D: 14% Q: 0% U: 0%	E: 43% D:57% Q:0% U:0%	E: 43% D: 29% Q: 14% U: 14%	E: 14% D: 43% Q: 14% U: 29%	E: 29% D: 43% Q: 14% U: 14%	E: 14% D:29% Q:14% U:43%	E: 14% D: 57% Q: 29% U: 0%	E: 29% D: 43% Q: 14% U: 14%
	Second level internal boundary	E: 29% D: 29% Q: 29% U: 14%	E: 86% D: 0% Q: 14% U: 0%	E: 29% D: 43% Q: 29% U: 0%	E: 14% D: 0% Q: 71% U: 14%	E: 0% D: 14% Q: 43% U: 43%	E: 14% D: 0% Q: 43% U: 43%	E: 14% D:0% Q:29% U:57%	E: 14% D: 0% Q: 57% U: 29%	E: 14% D: 14% Q: 29% U: 43%
	coastline	E: 100% D: 0% Q: 0% U: 0%	E: 100% D: 0% Q: 0% U: 0%	E: 86% D: 14% Q: 0% U: 0%	E: 100% D: 0% Q: 0% U: 0%	E: 100% D: 0% Q: 0% U: 0%	E: 100% D: 0% Q: 0% U: 0%	E: 86% D: 14% Q: 0% U: 0%	E: 100% D: 0% Q: 0% U: 0%	E: 100% D: 0% Q: 0% U: 0%
	National or regional park	E: 29% D: 43% Q: 14% U: 14%	E: 29% D: 14% Q: 29% U: 29%	E: 14% D: 0% Q: 43% U: 43%	E: 29% D: 29% Q: 29% U: 14%	E: 0% D: 29% Q: 29% U: 43%	E: 43% D: 43% Q: 14% U: 0%	E: 0% D: 0% Q: 43% U: 57%	E: 29% D: 43% Q: 29% U: 0%	E: 43% D: 43% Q: 14% U: 0%
Land cover	wood / forest	E: 71% D: 29% Q: 0% U: 0%	E: 0% D: 29% Q: 29% U: 43%	E: 0% D: 29% Q: 14% U: 57%	E: 86% D: 0% Q: 14% U: 0%	E: 29% D: 14% Q: 43% U: 14%	E: 100% D: 0% Q: 0% U: 0%	E: 14% D: 14% Q: 29% U: 43%	E: 43% D: 14% Q: 43% U: 0%	E: 57% D: 29% Q: 14% U: 0%
	Plantation or cultivated area	E: 43% D: 14% Q: 29% U: 14%	E: 0% D: 14% Q: 29% U: 57%	E: 0% D: 14% Q: 29% U: 57%	E: 86% D: 0% Q: 14% U: 0%	E: 14% D: 0% Q: 43% U: 43%	E: 100% D: 0% Q: 0% U: 0%	E: 14% D: 14% Q: 14% U: 57%	E: 0% D: 29% Q: 57% U: 14%	E: 29% D: 29% Q: 29% U: 14%

	Extensive non vegetated area	E: 57% D: 14% Q: 29% U: 0%	E: 0% D: 14% Q: 29% U: 57%	E: 0% D: 29% Q: 14% U: 57%	E: 86% D: 0% Q: 14% U: 0%	E: 14% D: 0% Q: 43% U: 43%	E: 100% D: 0% Q: 0% U: 0%	E: 14% D: 14% Q: 14% U: 57%	E: 0% D: 29% Q: 57% U: 14%	E: 29% D: 29% Q: 29% U: 14%
Other features	Major historic/ cultural site	E: 14% D: 71% Q: 0% U: 14%	E: 0% D: 0% Q: 29% U: 71%	E: 14% D: 0% Q: 29% U: 57%	E: 29% D: 14% Q: 14% U: 43%	E: 0% D: 0% Q: 14% U: 86%	E: 14% D: 14% Q: 14% U: 57%	E: 0% D: 0% Q: 0% U: 100%	E: 57% D: 14% Q: 29% U: 0%	E: 14% D: 0% Q: 57% U: 29%
	landmark	E: 29% D:57% Q: 0% U%14%	E: 0% D: 0% Q: 29% U: 71%	E: 14% D: 0% Q: 29% U: 57%	E: 14% D: 14% Q: 29% U: 43%	E: 0% D:0% Q: 29% U:71%	E: 14% D: 14% Q: 14% U: 57%	E: 0% D: 0% Q: 0% U: 100%	E: 57% D: 14% Q: 29% U: 0%	E: 14% D: 0% Q: 57% U: 29%
Topographic Features	Key spot heights	E: 71% D: 29% Q: 0% U: 0%	E: 0% D: 0% Q: 14% U: 86%	E: 0% D: 0% Q: 29% U: 71%	E: 0% D: 14% Q: 43% U: 43%	E: 86% D: 14% Q: 0% U: 0%	E: 14% D: 29% Q: 29% U: 29%	E: 0% D: 14% Q: 43% U: 43%	E: 0% D: 29% Q: 43% U: 29%	E: 14% D: 57% Q: 14% U: 14%
	General relief information	E: 71% D: 29% Q: 0% U: 0%	E: 0% D: 0% Q: 14% U: 86%	E: 0% D: 0% Q: 43% U: 57%	E: 43% D: 29% Q: 14% U: 14%	E: 86% D: 0% Q: 0% U: 14%	E: 14% D: 57% Q: 29% U: 0%	E: 14% D: 57% Q: 29% U: 0%	E: 29% D: 43% Q: 29% U: 0%	E: 43% D: 43% Q: 14% U: 0%
	Detail height information	E: 57% D: 29% Q: 0% U: 14%	E: 0% D: 0% Q: 14% U: 86%	E: 0% D: 0% Q: 43% U: 57%	E: 0% D: 29% Q: 29% U: 43%	E: 71% D: 29% Q: 0% U: 0%	E: 14% D: 14% Q: 29% U: 43%	E: 0% D: 14% Q: 43% U: 43%	E: 0% D: 43% Q: 29% U: 29%	E: 43% D: 14% Q: 14% U: 29%
transport	vehicular ferry	E: 57% D: 14% Q: 14% U: 14%	E: 14% D: 14% Q: 29% U: 43%	E: 0% D: 14% Q: 43% U: 43%	E: 14% D: 14% Q: 43% U: 29%	E: 0% D: 0% Q: 29% U: 71%	E: 0% D: 14% Q: 43% U: 43%	E: 0% D: 0% Q: 14% U: 86%	E: 86% D: 0% Q: 14% U: 0%	E: 0% D: 0% Q: 57% U: 43%

	passenger ferry	E: 57% D: 14% Q: 14% U: 14%	E: 0% D: 29% Q: 29% U: 43%	E: 0% D: 14% Q: 43% U: 43%	E: 0% D: 29% Q: 43% U: 29%	E: 0% D: 0% Q: 29% U: 71%	E: 0% D: 14% Q: 43% U: 43%	E: 0% D: 0% Q: 14% U: 86%	E: 86% D: 0% Q: 14% U: 0%	E: 0% D: 0% Q: 57% U: 43%
	Main line railway	E: 71% D: 14% Q: 0% U: 14%	E: 14% D: 57% Q: 0% U: 29%	E: 14% D: 14% Q: 29% U: 43%	E: 29% D: 29% Q: 29% U: 14%	E: 0% D: 14% Q: 29% U: 57%	E: 29% D: 43% Q: 14% U: 14%	E: 14% D: 14% Q: 14% U: 57%	E: 86% D: 0% Q: 14% U: 0%	E:14% D:57% Q:14% U:14%
	Other railway	E: 43% D: 29% Q: 29% U: 0%	E: 0% D: 14% Q: 29% U: 57%	E: 14% D: 0% Q: 43% U: 43%	E: 14% D: 14% Q: 29% U: 43%	E: 0% D: 0% Q: 29% U: 71%	E: 14% D: 14% Q: 29% U: 43%	E: 0% D: 0% Q: 14% U: 86%	E: 57% D: 14% Q: 29% U: 0%	E: 14% D: 0% Q: 29% U: 57%
	Airport	E: 43% D: 29% Q: 14% U: 0%	E: 14% D: 29% Q: 0% U: 43%	E: 0% D: 29% Q: 14% U: 43%	E: 29% D: 29% Q: 14% U: 14%	E: 0% D: 0% Q: 43% U: 43%	E: 29% D: 14% Q: 29% U: 14%	E: 0% D: 14% Q: 29% U: 43%	E: 57% D: 29% Q: 0% U: 0%	E: 14% D: 29% Q: 29% U: 14%

Appendix G

comparison of data selected using SI scores with data collected from existing maps and questionnaire: topographic maps.

features	inclusion score ld	questionnaire	existing maps	SI								
				1:250000			1:500000			1:1000000		
				LD:16	LD:54	LD:101	LD:18	LD:56	LD:104	LD:110	LD:58	LD:105
coastline	10	E:100%	38%	*	*	*	*	*	*	*	*	*
main river	8	E:100%	88%	*	*	*	*	*	*		*	*
2nd class river	6	E:71%	59%	*	*	*		*	*			*
lake	10	E:100%	77%	*	*	*	*	*	*	*	*	*
international boundary	10	E:86%	74%	*	*	*	*	*	*	*	*	*
state boundary	8	E,D,Q:29%	26%	*	*	*	*	*	*		*	*
county boundary	6	E:57%	41%	*	*	*		*	*			*
capital, city	10	E:86%	100%	*	*	*	*	*	*	*	*	*
large town	8	E:57%	85%	*	*	*	*	*	*		*	*
2nd class town	6			*	*	*		*	*			*
urban area	6	E:14%	46%	*	*	*		*	*			*
motorway	10	E:86%	80%	*	*	*	*	*	*	*	*	*
primary route	6	E:86%	54%	*	*	*		*	*			*
other road	6	E:43%	49%	*	*	*		*	*			*
railway	6	E:71%	56%	*	*	*		*	*			*
main relief	10	E:71%	62%	*	*	*	*	*	*	*	*	*
minor relief	4	E:57%	33%		*	*			*			

comparison of data selected using SI scores with data collected from existing maps and questionnaire: environmental maps

features	inclusion score ld	questionnaire	existing maps	SI								
				1:250000			1:500000			1:1000000		
				LD:16	LD:54	LD:101	LD:18	LD:56	LD:104	LD:110	LD:58	LD:105
coastline	10	E:100%	95%	*	*	*	*	*	*	*	*	*
main river	10	E:100%	91%	*	*	*	*	*	*	*	*	*
2nd class river	6	E:57%	60%	*	*	*		*	*			*
lake	10	E:100%	82%	*	*	*	*	*	*	*	*	*
international boundary	10	E:71%	64%	*	*	*	*	*	*	*	*	*
state boundary	6	E:14%	18%	*	*	*		*	*			*
county boundary	4	E:29%,D:43%	46%		*	*			*			
capital, city	6	E:71%	87%	*	*	*		*	*			*
large town	6	E:29%,D:57%	73%	*	*	*		*	*			*
2nd class town	2					*						
urban area	4	E:14%	46%		*	*			*			
motorway	4	E:29%,D:57%	41%		*	*			*			
primary route	2	E:14%,D:57%	23%			*						
other road	2	E:14%	14%			*						
railway	4	E:14%,D:57%	27%		*	*			*			
main relief	4	E:43%	27%		*	*			*			
minor relief	2	E:43%	5%			*						

comparison of data selected using SI scores with data collected from existing maps and questionnaire:

climate maps

features	inclusion score ld	questionnaire	existing maps	SI								
				1:250000			1:500000			1:1000000		
				LD:16	LD:54	LD:101	LD:18	LD:56	LD:104	LD:110	LD:58	LD:105
coastline	10	E:86%	100%	*	*	*	*	*	*	*	*	*
main river	10	E:43%	25%	*	*	*	*	*	*	*	*	*
2nd class river	8	E:14%	25%	*	*	*	*	*	*		*	*
lake	10	E:71%	75%	*	*	*	*	*	*	*	*	*
international boundary	10	E:57%	50%	*	*	*	*	*	*	*	*	*
state boundary	6	E:14%	75%	*	*	*		*	*			*
county boundary	4	E:14%	50%		*	*			*			
capital, city	8	E:71%	100%	*	*	*	*	*	*		*	*
large town	8	E:29%	100%	*	*	*	*	*	*		*	*
2nd class town	0											
urban area	4	E:0%	50%		*	*			*			
motorway	4	E:14%	50%		*	*			*			
primary route	4	E:14%	50%		*	*			*			
other road	2	E:0%	25%			*						
railway	2	E:14%,D:57%	25%			*						
main relief	2	E:14%	25%			*						
minor relief	0	E:0%	50%									

comparison of data selected using SI scores with data collected from existing maps and questionnaire:

land use maps

features	inclusion score ld	questionnaire	existing maps	SI								
				1:250000			1:500000			1:1000000		
				LD:16	LD:54	LD:101	LD:18	LD:56	LD:104	LD:110	LD:58	LD:105
coastline	10	E:100%	73%	*	*	*	*	*	*	*	*	*
main river	8	E:86%	82%	*	*	*	*	*	*		*	*
2nd class river	6	E:57%	64%	*	*	*		*	*			*
lake	8	E:100%	82%	*	*	*	*	*	*		*	*
international boundary	10	E:86%	36%	*	*	*	*	*	*	*	*	*
state boundary	6	E:14%	18%	*	*	*		*	*			*
county boundary	2	E:43%	9%			*						
capital, city	10	E:100%	100%	*	*	*	*	*	*	*	*	*
large town	4	E:86%	36%		*	*			*			
2nd class town	0											
urban area	8	E:14%	82%	*	*	*	*	*	*		*	*
motorway	6	E:43%	64%	*	*	*		*	*			*
primary route	4	E:29%,D:43%	18%		*	*			*			
other road	0	E:14%	0%									
railway	2	E:29%	0%			*						
main relief	0	E:43%	0%									
minor relief	0	E:0%	0%									

comparison of data selected using SI scores with data collected from existing maps and questionnaire:

communication maps

features	inclusion score ld	questionnaire	existing maps	SI								
				1:250000			1:500000			1:1000000		
				LD:16	LD:54	LD:101	LD:18	LD:56	LD:104	LD:110	LD:58	LD:105
coastline	10	E:100%	89%	*	*	*	*	*	*	*	*	*
main river	10	E:86%	97%	*	*	*	*	*	*	*	*	*
2nd class river	6	E:57%	58%	*	*	*		*	*			*
lake	10	E:100%	94%	*	*	*	*	*	*	*	*	*
international boundary	10	E:100%	72%	*	*	*	*	*	*	*	*	*
state boundary	8	E:14%	19%	*	*	*	*	*	*		*	*
county boundary	6	E:14%,D:57%	58%	*	*	*		*	*			*
capital, city	10	E:100%	100%	*	*	*	*	*	*	*	*	*
large town	8	E:71%	89%	*	*	*	*	*	*		*	*
2nd class town	6			*	*	*		*	*			*
urban area	6	E:14%,D:43%	50%	*	*	*		*	*			*
motorway	8	E:100%	92%	*	*	*	*	*	*		*	*
primary route	6	E:100%	47%	*	*	*		*	*			*
other road	6	E:43%	56%	*	*	*		*	*			*
railway	6	E:86%	44%	*	*	*		*	*			*
main relief	2	E:29%,D:43%	31%			*						
minor relief	0	E:0%,D:43%	8%									

comparison of data selected using SI scores with data collected from existing maps and questionnaire:

political maps

features	inclusion score ld	questionnaire	existing maps	SI								
				1:250000			1:500000			1:1000000		
				LD:16	LD:54	LD:101	LD:18	LD:56	LD:104	LD:110	LD:58	LD:105
coastline	10	E:100%	64%	*	*	*	*	*	*	*	*	*
main river	6	E:29%,D:57%	57%	*	*	*		*	*			*
2nd class river	4	E:0%	36%		*	*			*			
lake	10	E:57%	43%	*	*	*	*	*	*	*	*	*
international boundary	10	E:100%	79%	*	*	*	*	*	*	*	*	*
state boundary	8	E:86%	57%	*	*	*	*	*	*		*	*
county boundary	8	E:86%	79%	*	*	*		*	*			*
capital, city	10	E:86%	93%	*	*	*	*	*	*	*	*	*
large town	8	E:29%	86%	*	*	*	*	*	*		*	*
2nd class town	6			*	*	*		*	*			*
urban area	6	E:14%	57%	*	*	*		*	*			*
motorway	8	E:43%	72%	*	*	*	*	*	*		*	*
primary route	6	E:29%,D:57%	57%	*	*	*		*	*			*
other road	4	E:14%	14%		*	*			*			
railway	6	E:14%,D:57%	57%	*	*	*		*	*			*
main relief	4	E:0%	21%		*	*			*			
minor relief	0	E:0%	7%									

comparison of data selected using SI scores with data collected from existing maps and questionnaire:

population maps

features	inclusion score ld	questionnaire	existing maps	SI								
				1:250000			1:500000			1:1000000		
				LD:16	LD:54	LD:101	LD:18	LD:56	LD:104	LD:110	LD:58	LD:105
coastline	10	E:86%	100%	*	*	*	*	*	*	*	*	*
main river	10	E:29%,D:57%	100%	*	*	*	*	*	*	*	*	*
2nd class river	8	E:0%	89%	*	*	*	*	*	*		*	*
lake	8	E:43%	78%	*	*	*	*	*	*		*	*
international boundary	10	E:100%	67%	*	*	*	*	*	*	*	*	*
state boundary	4	E:29%,D:43%	44%		*	*			*			
county boundary	4	E:43%,D:57%	33%		*	*			*			
capital, city	10	E:86%	100%	*	*	*	*	*	*	*	*	*
large town	10	E:57%	100%	*	*	*	*	*	*	*	*	*
2nd class town	10			*	*	*	*	*	*	*	*	*
urban area	6	E:29%	56%	*	*	*		*	*			*
motorway	2	E:14%,D:43%	22%			*						
primary route	2	E:14%,D:29%	11%			*						
other road	0	E:14%	0%									
railway	0	E:14%	0%									
main relief	0	E:0%	0%									
minor relief	0	E:0%	0%									

comparison of data selected using SI scores with data collected from existing maps and questionnaire: cover maps

features	inclusion score ld	questionnaire	existing maps	SI								
				1:250000			1:500000			1:1000000		
				LD:16	LD:54	LD:101	LD:18	LD:56	LD:104	LD:110	LD:58	LD:105
coastline	10	E:100%	86%	*	*	*	*	*	*	*	*	*
main river	8	E:86%	93%	*	*	*	*	*	*		*	*
2nd class river	8	E:57%	86%	*	*	*	*	*	*		*	*
lake	10	E:100%	71%	*	*	*	*	*	*	*	*	*
international boundary	10	E:71%	64%	*	*	*	*	*	*	*	*	*
state boundary	6	E:14%	14%	*	*	*		*	*			*
county boundary	2	E:29%,D:43%	21%			*						
capital, city	8	E:86%	86%	*	*	*	*	*	*		*	*
large town	6	E:43%	57%	*	*	*		*	*			*
2nd class town	2					*						
urban area	6	E:14%	64%	*	*	*		*	*			*
motorway	6	E:43%	64%	*	*	*		*	*			*
primary route	6	E:43%	50%	*	*	*		*	*			*
other road	2	E:14%	0%			*						
railway	2	E:29%,D:43%	7%			*						
main relief	8	E:14%,D:57%	14%	*	*	*	*	*	*		*	*
minor relief	4	E:14%	14%		*	*			*			

comparison of data selected using SI scores with data collected from existing maps and questionnaire:

relief maps

features	inclusion score ld	questionnaire	existing maps	SI								
				1:250000			1:500000			1:1000000		
				LD:16	LD:54	LD:101	LD:18	LD:56	LD:104	LD:110	LD:58	LD:105
coastline	10	E:100%	75%	*	*	*	*	*	*	*	*	*
main river	10	E:71%	100%	*	*	*	*	*	*	*	*	*
2nd class river	8	E:71%	88%	*	*	*	*	*	*		*	*
lake	10	E:86%	100%	*	*	*	*	*	*	*	*	*
international boundary	10	E:43%	50%	*	*	*	*	*	*	*	*	*
state boundary	6	E:0%	13%	*	*	*		*	*			*
county boundary	2	E:14%	25%			*						
capital, city	8	E:71%	88%	*	*	*	*	*	*		*	*
large town	6	E:29%	63%	*	*	*		*	*			*
2nd class town	2					*						
urban area	6	E:0%	63%	*	*	*		*	*			*
motorway	4	E:14%	50%		*	*			*			
primary route	4	E:14%	50%		*	*			*			
other road	2	E:0%	13%			*						
railway	2	E:0%	13%			*						
main relief	10	E:86%	100%	*	*	*	*	*	*	*	*	*
minor relief	8	E:71%	25%	*	*	*	*	*	*		*	*

Appendix H:

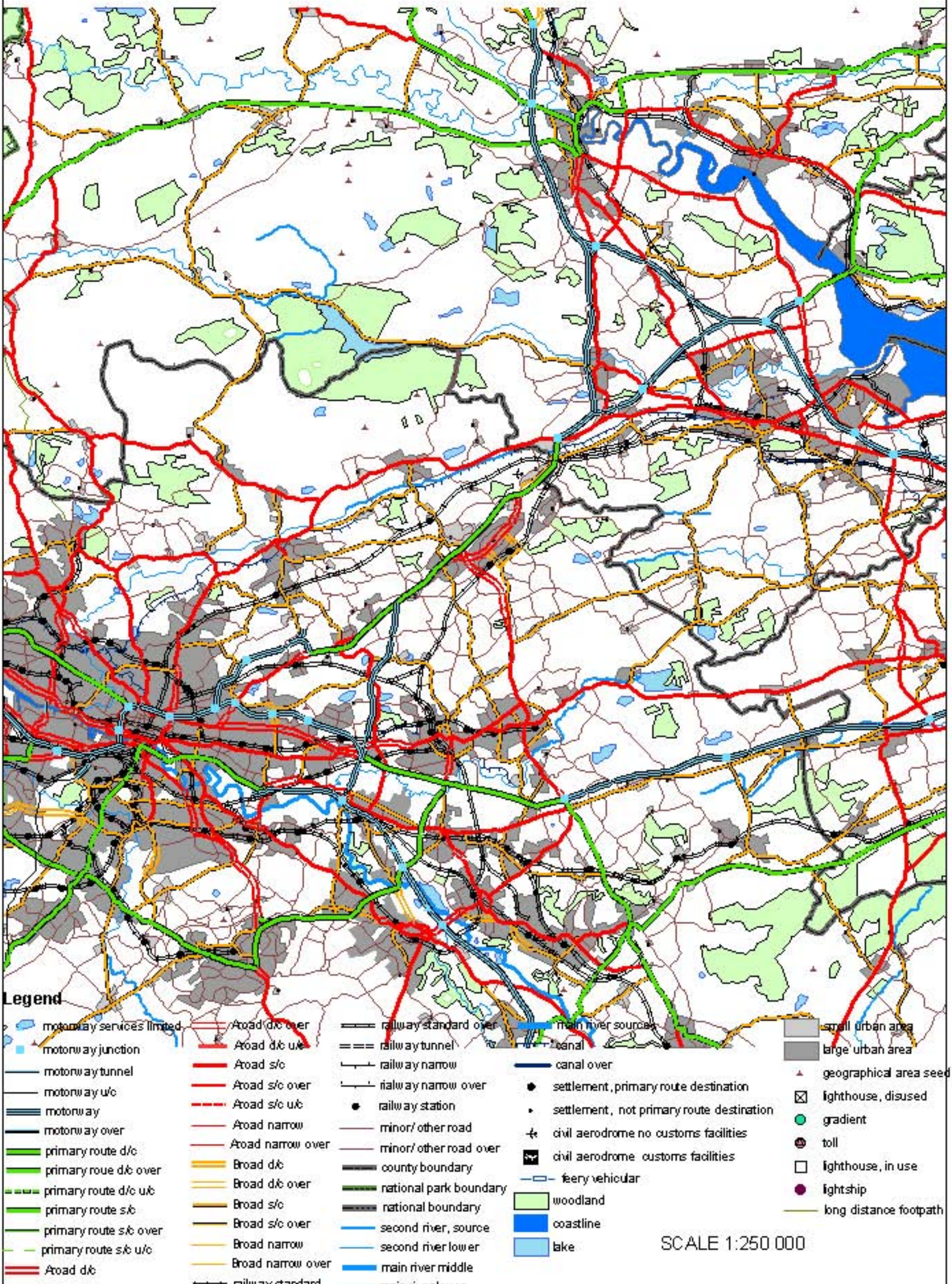
communication map LD:1

Legend

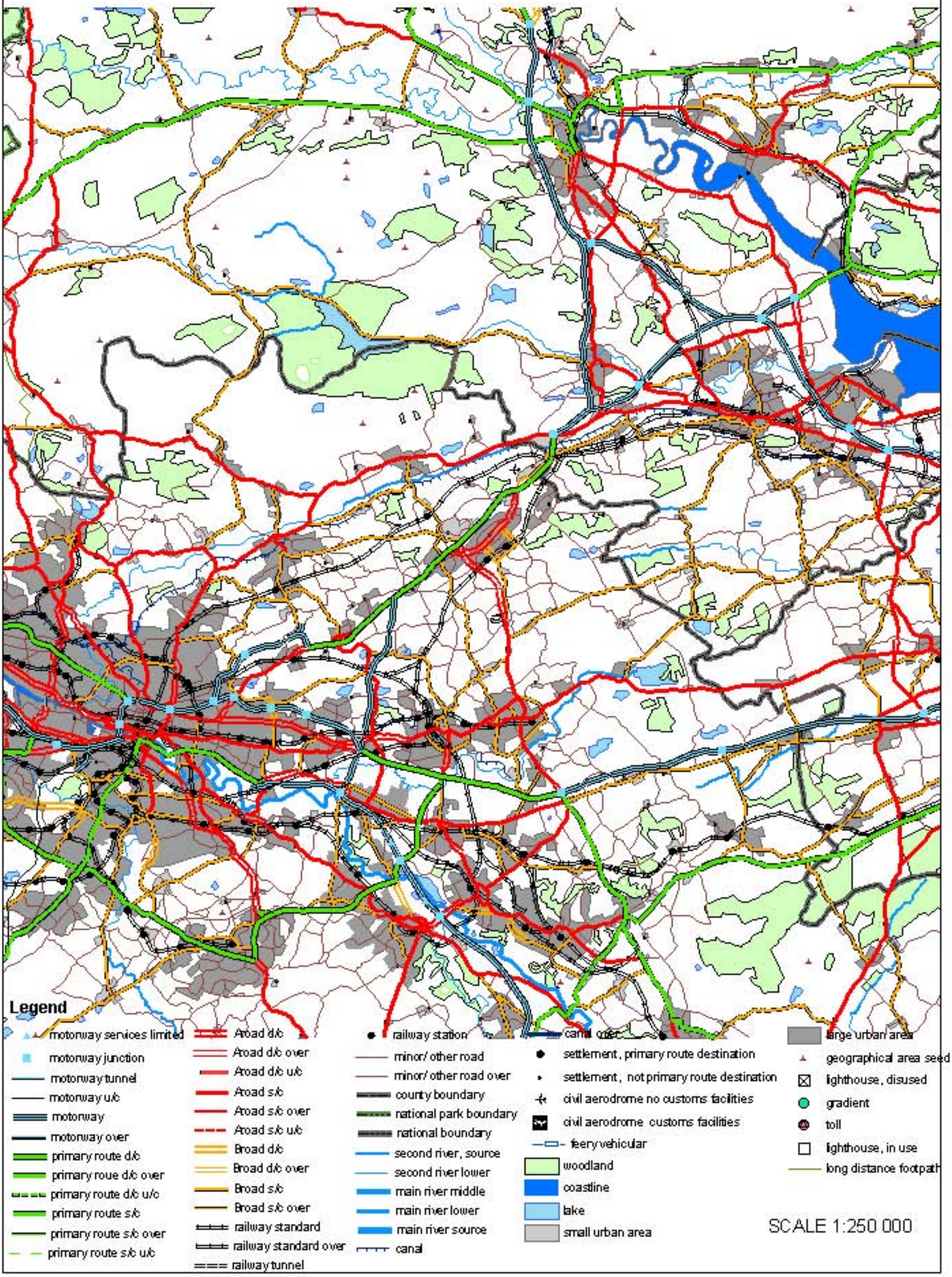
SCALE 1:250 000

- motorway services limited
- motorway junction
- motorway u/c
- motorway
- motorway over
- primary route d/c
- primary roue d/c over
- primary route s/c
- primary route s/c over
- Aroad d/c
- Aroad d/c over
- Aroad s/c
- Aroad s/c over
- Broad d/c
- Broad d/c over
- Broad s/c
- Broad s/c over
- railway standard
- railway standard over
- minor/ other road
- minor/ other road over
- county boundary
- national boundary
- second river, source
- second river lower
- main river middle
- main river lower
- main river source
- canal
- canal over
- settlement, primaryroute destination
- settlement, not primaryroute destination
- civil aerodrome no customs facilities
- civil aerodrome customs facilities
- feeryvehicular
- coastline
- lake
- small urban area
- large urban area
- geographical area seec
- gradient
- toll

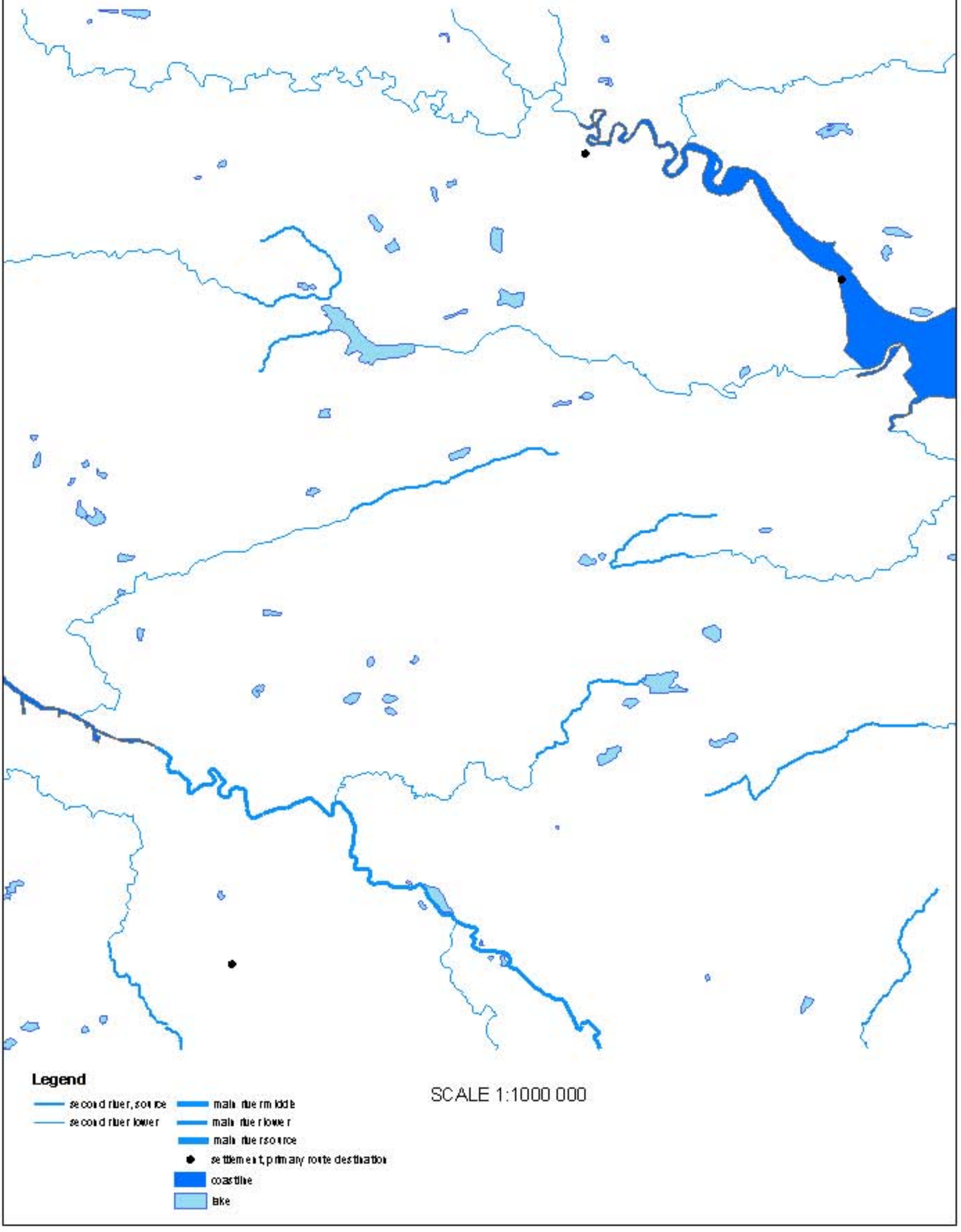
communication map LD:10



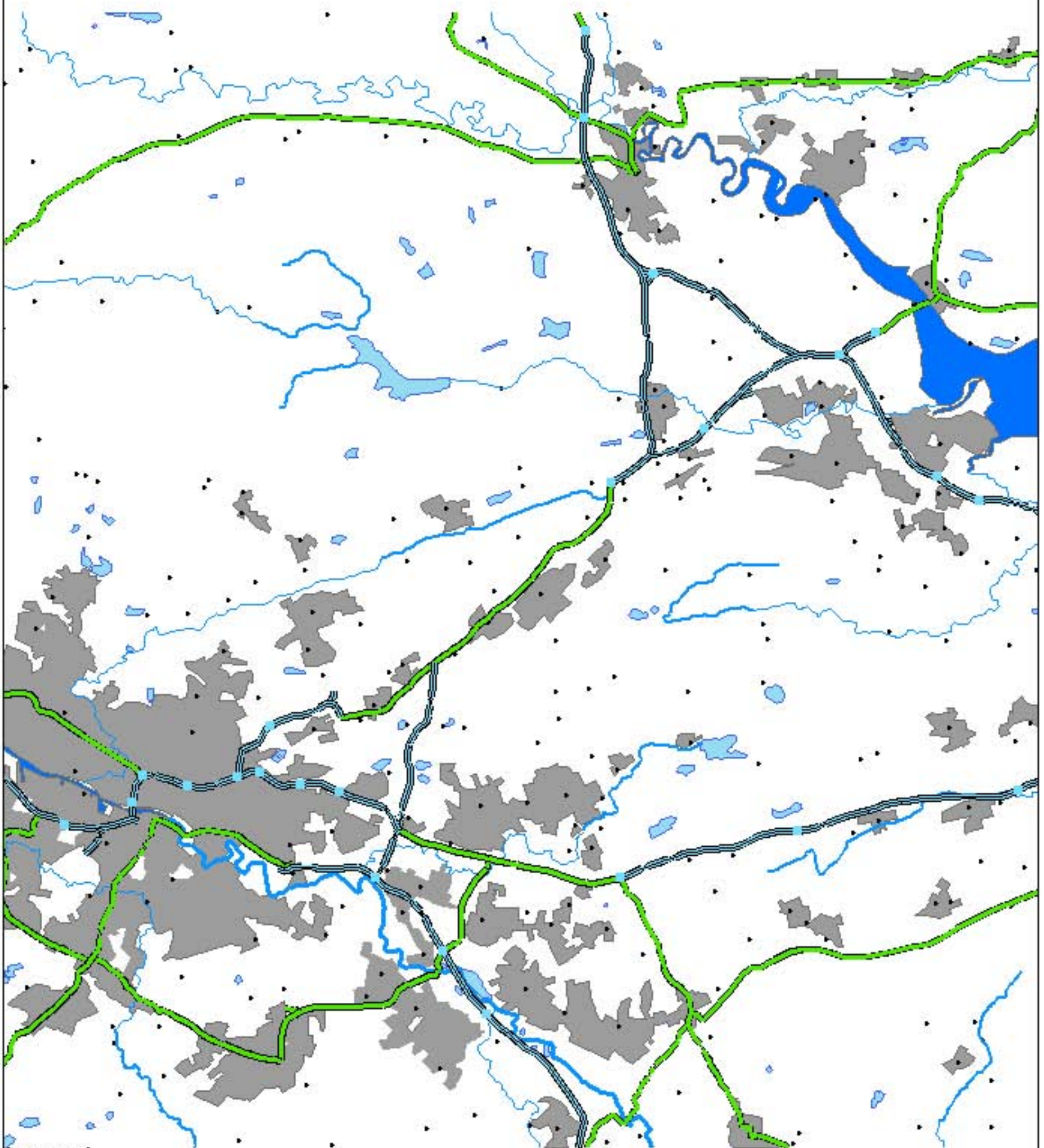
communication map LD:5



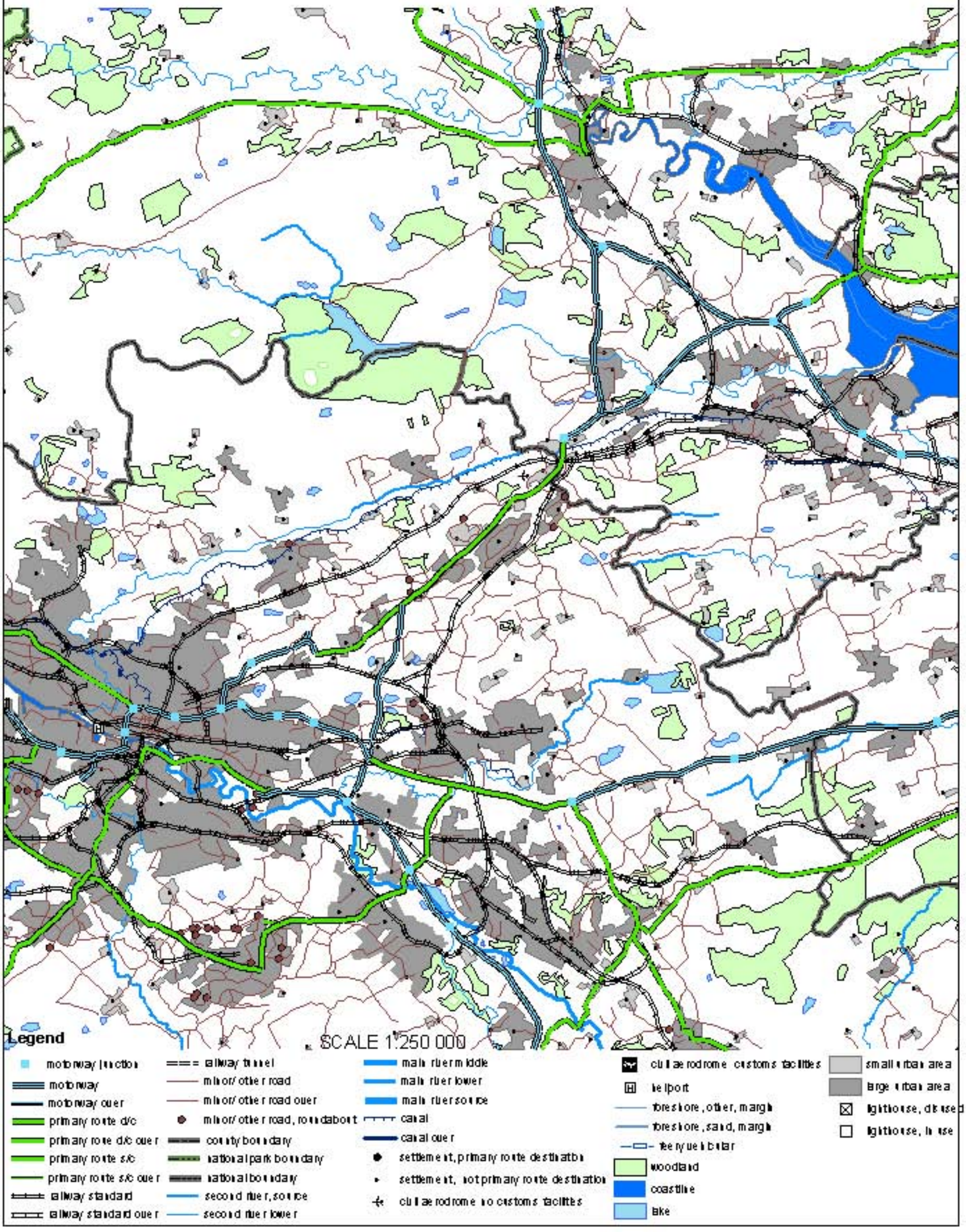
land cover map LD:5



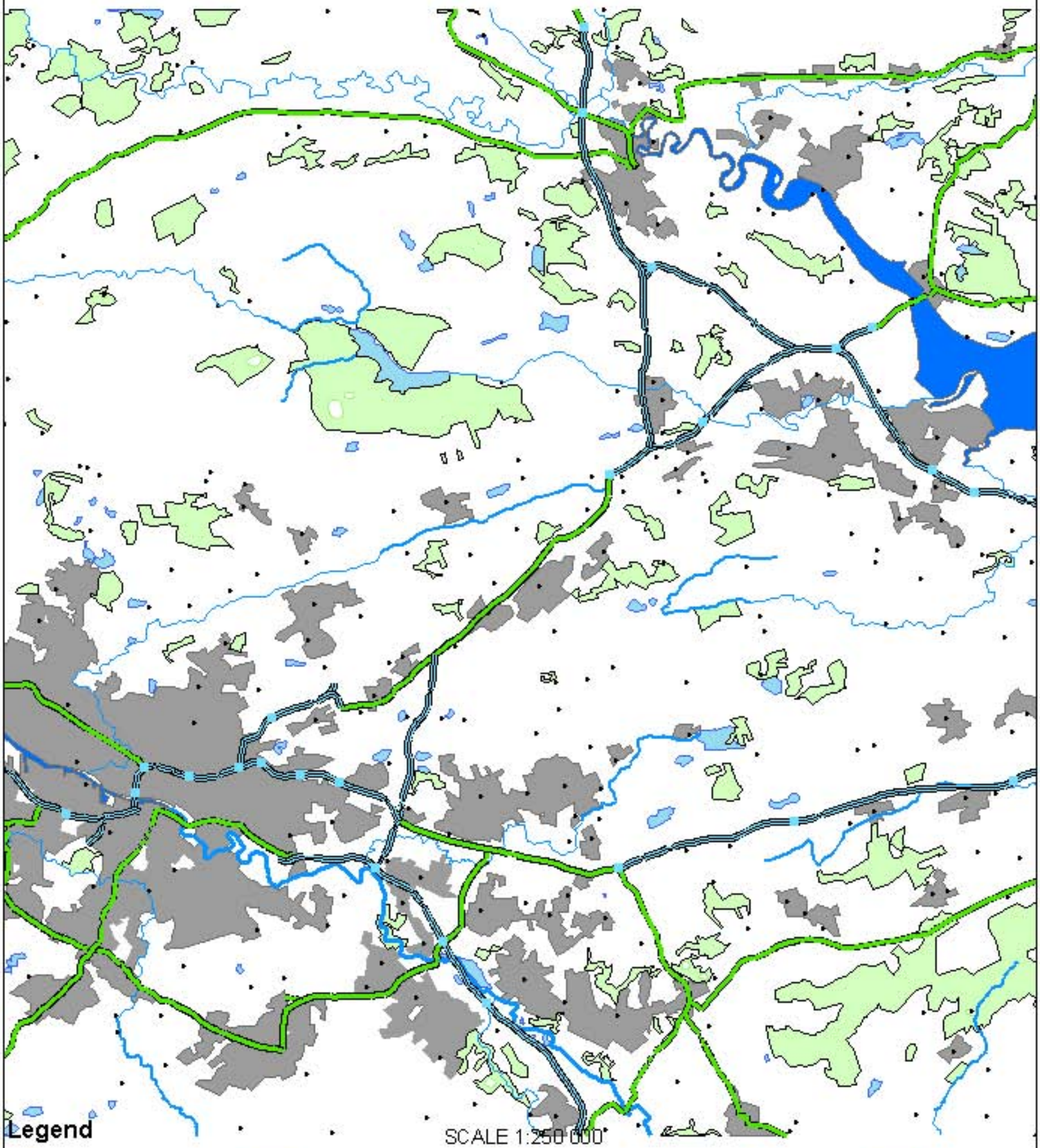
land cover map LD:1



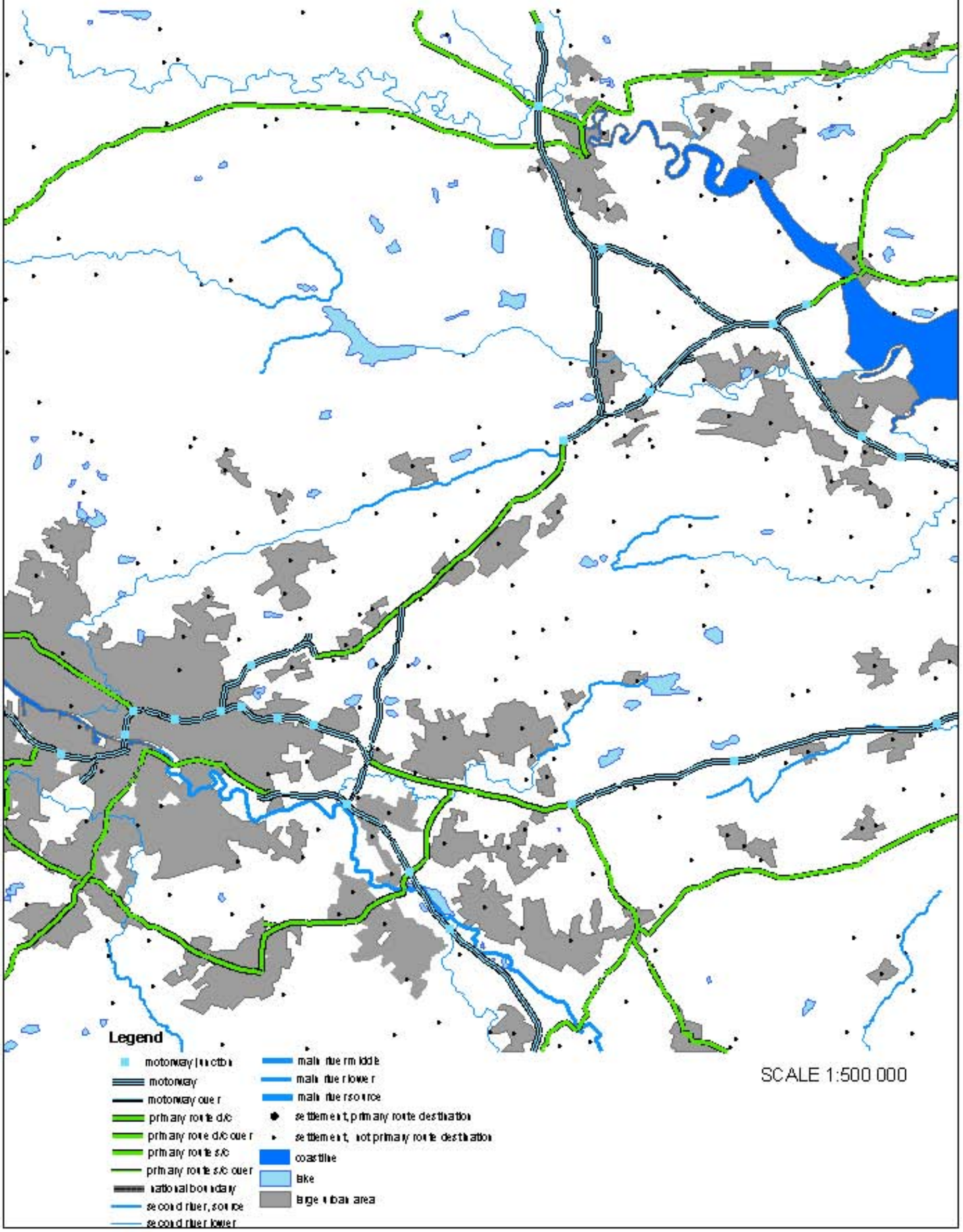
land cover map LD:10



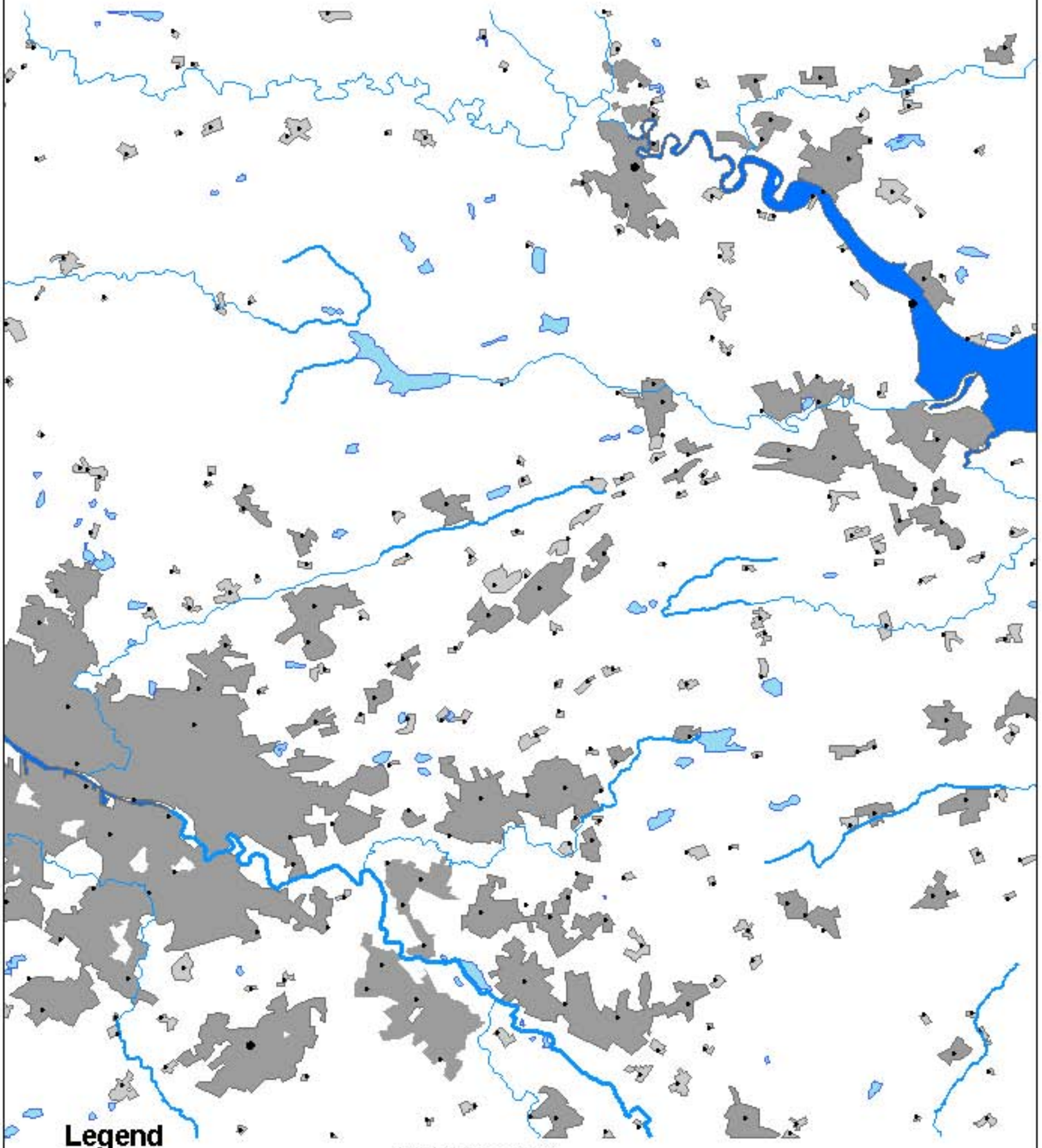
land cover map LD:5



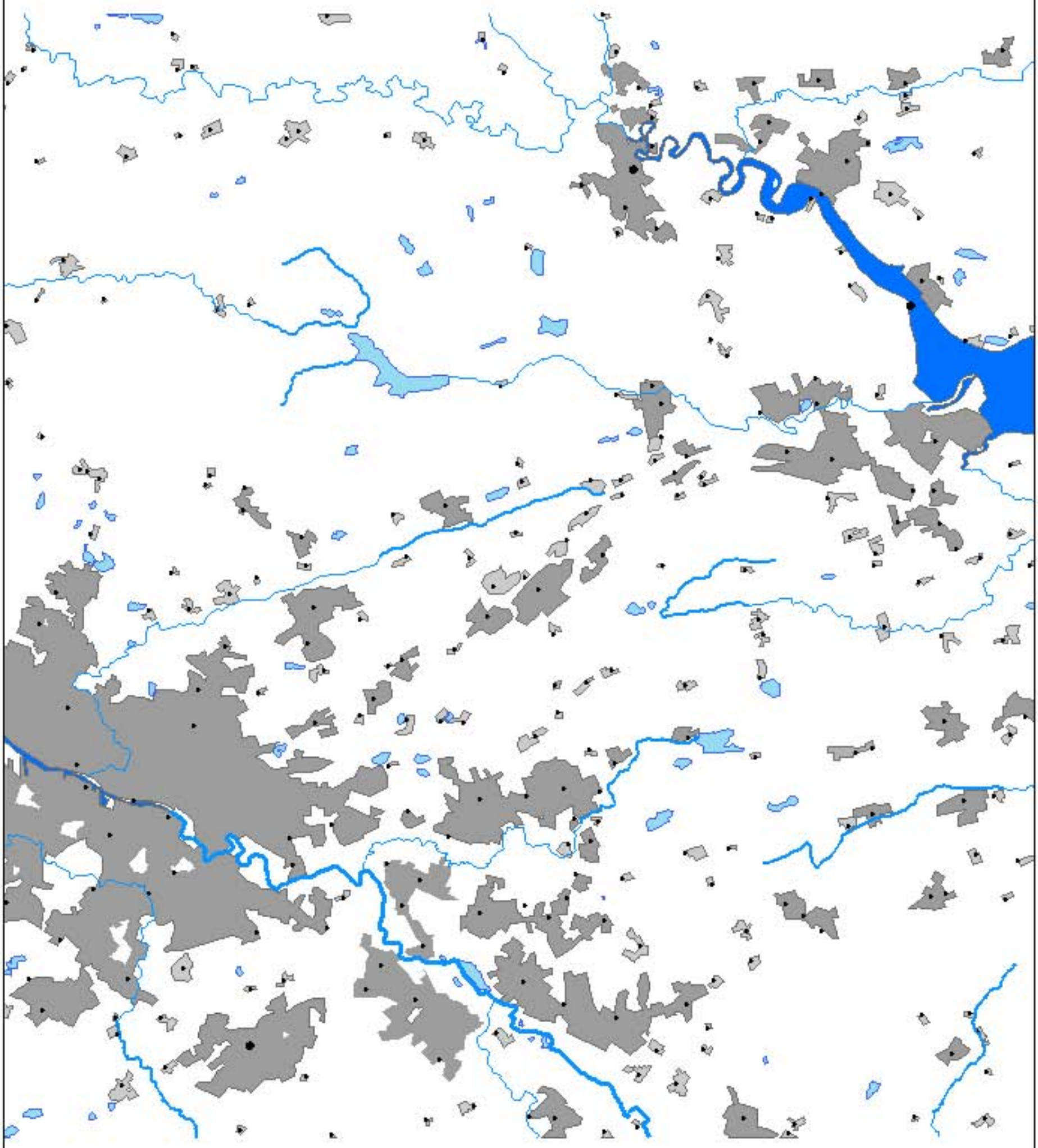
land cover map LD:5



population map LD:5



population map LD:1

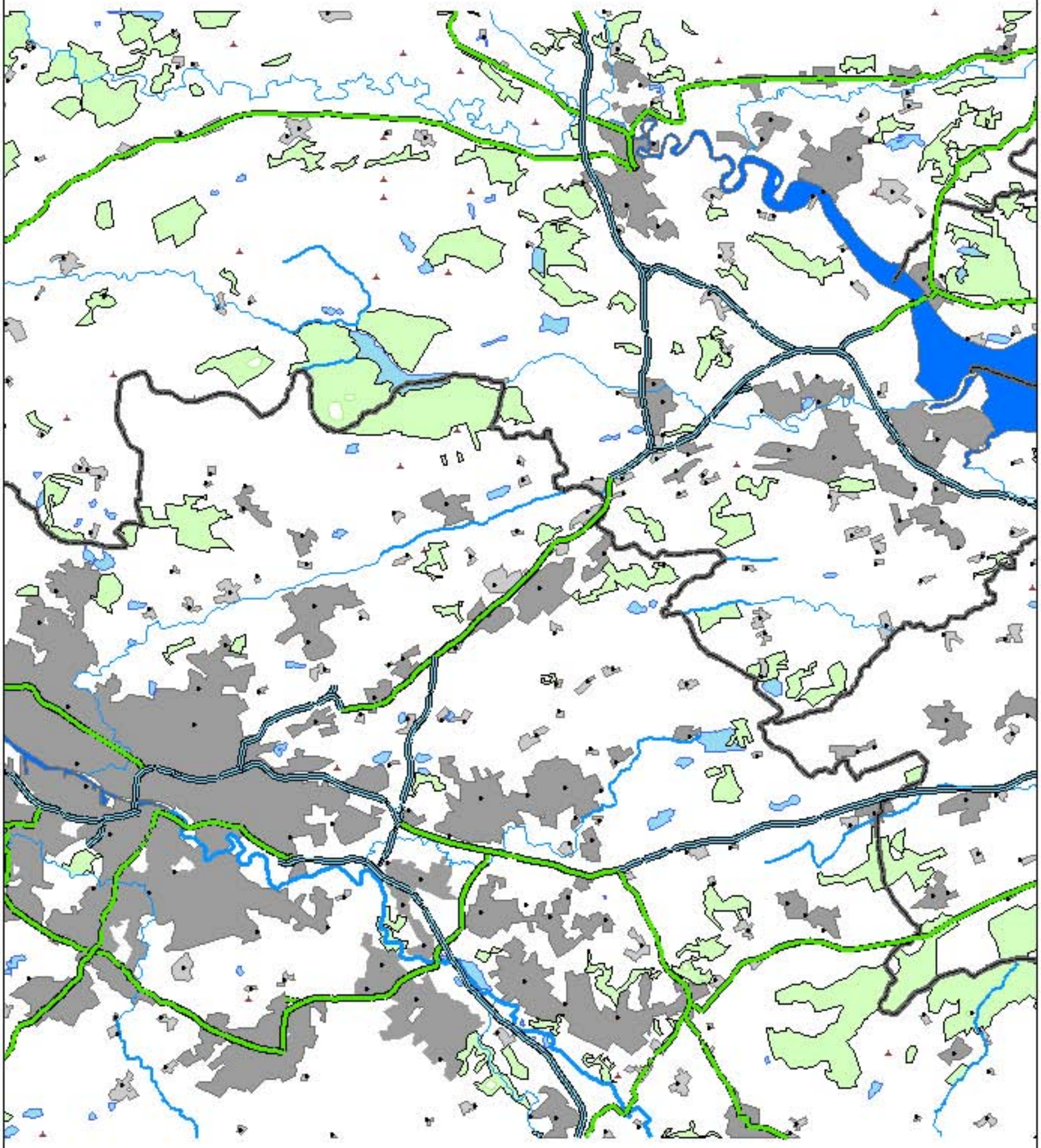


SCALE 1:250 000

Legend

- national boundary
- second river, source
- second river lower
- main river middle
- main river lower
- main river source
- settlement, primary route destination
- settlement, not primary route destination
- coastline
- lake
- small urban area
- large urban area

population map LD:10

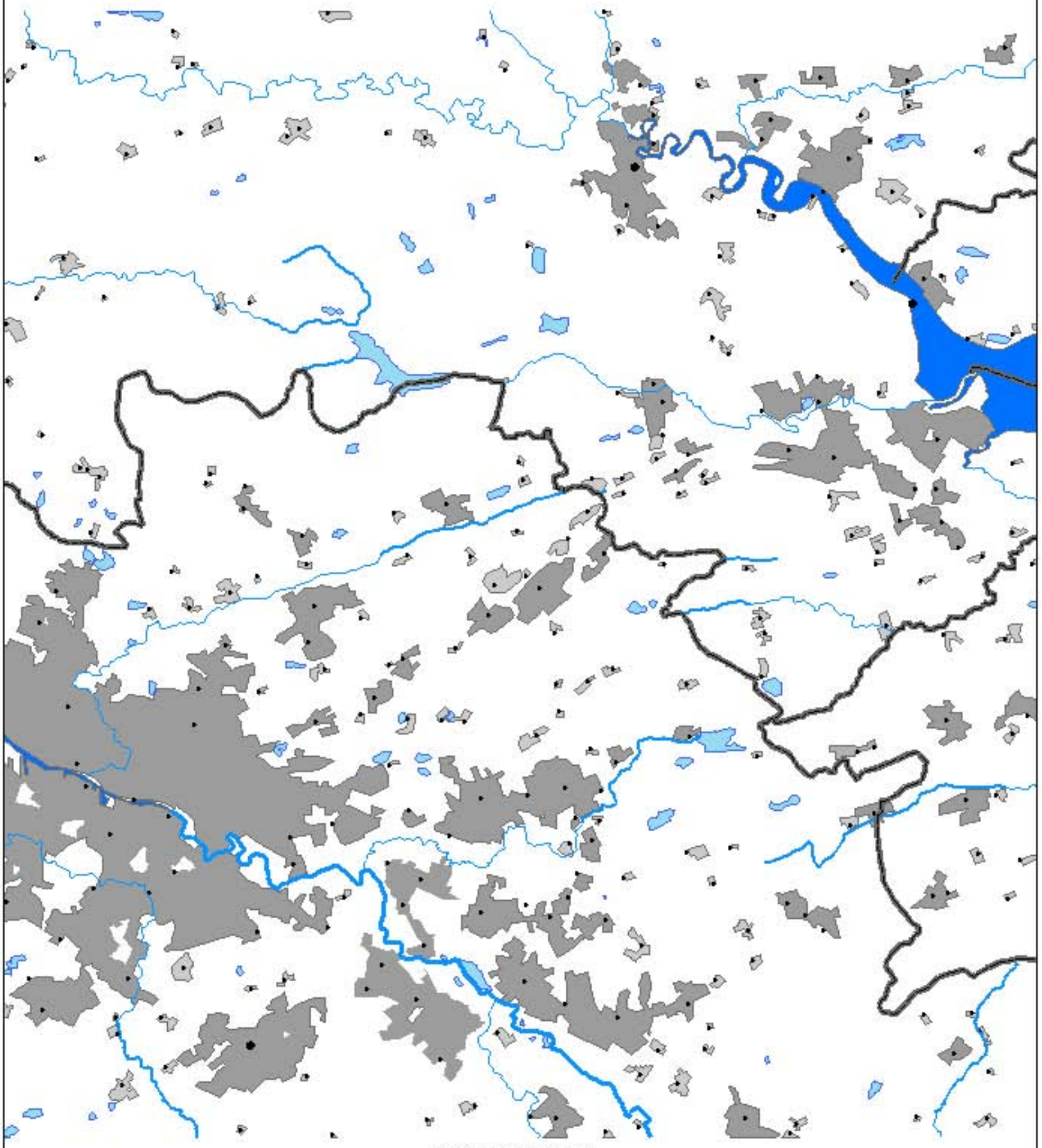


SCALE 1:250 000

Legend

- motorway
- motorway over
- primary route d/c
- primary roue d/c over
- primary route s/c
- primary route s/c over
- county boundary
- national boundary
- second river, source
- second river lower
- main river middle
- main river lower
- main river source
- settlement, primary route destination
- settlement, not primary route destination
- coastline
- lake
- small urban area
- large urban area
- woodland
- geographical area seed

population map LD:5

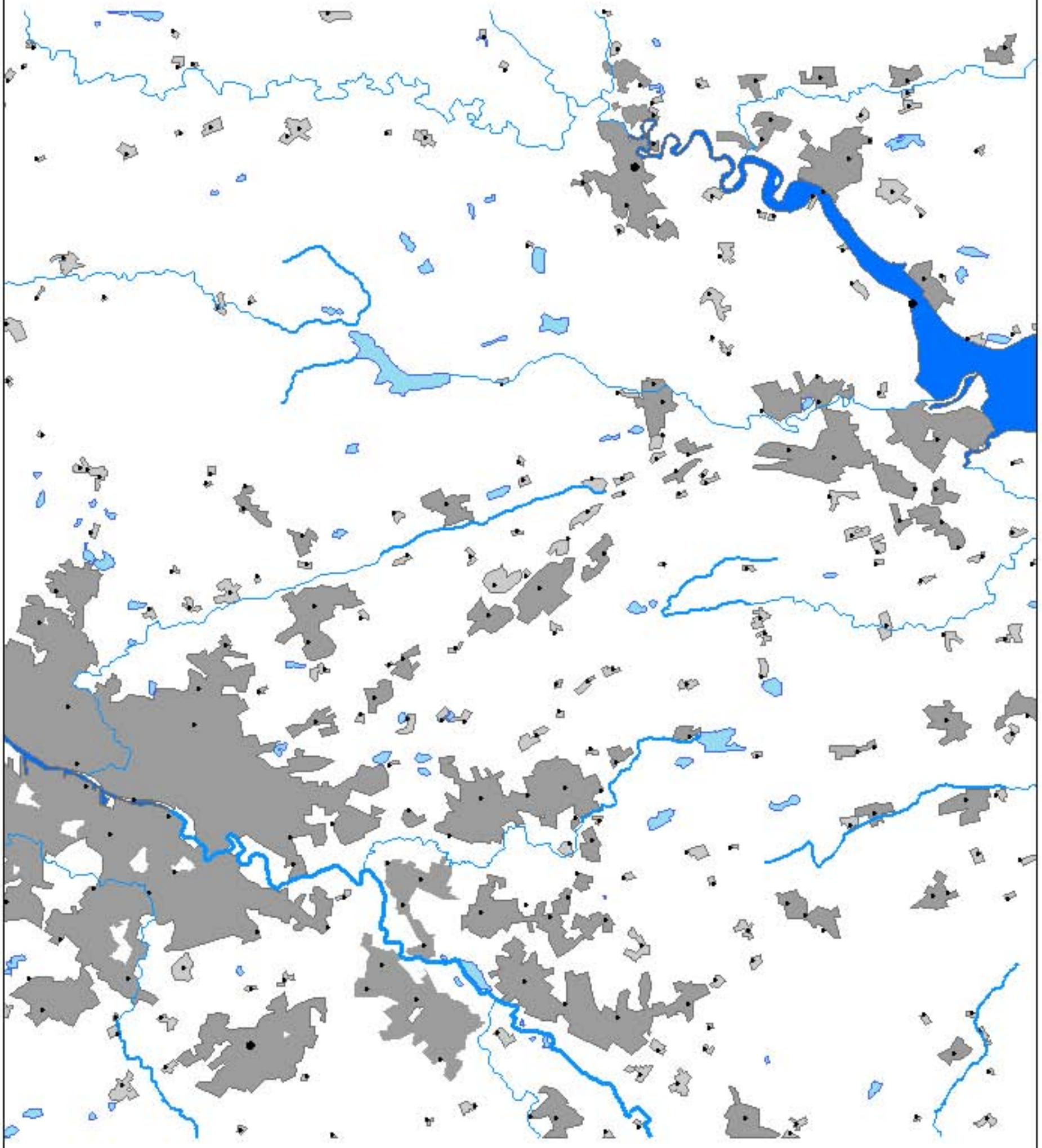


SCALE 1:250 000

Legend

- county boundary
- second river, source
- second river lower
- main river middle
- main river lower
- main river source
- settlement, primary route destination
- settlement, not primary route destination
- coastline
- lake
- small urban area
- large urban area
- national boundary

population map LD:5

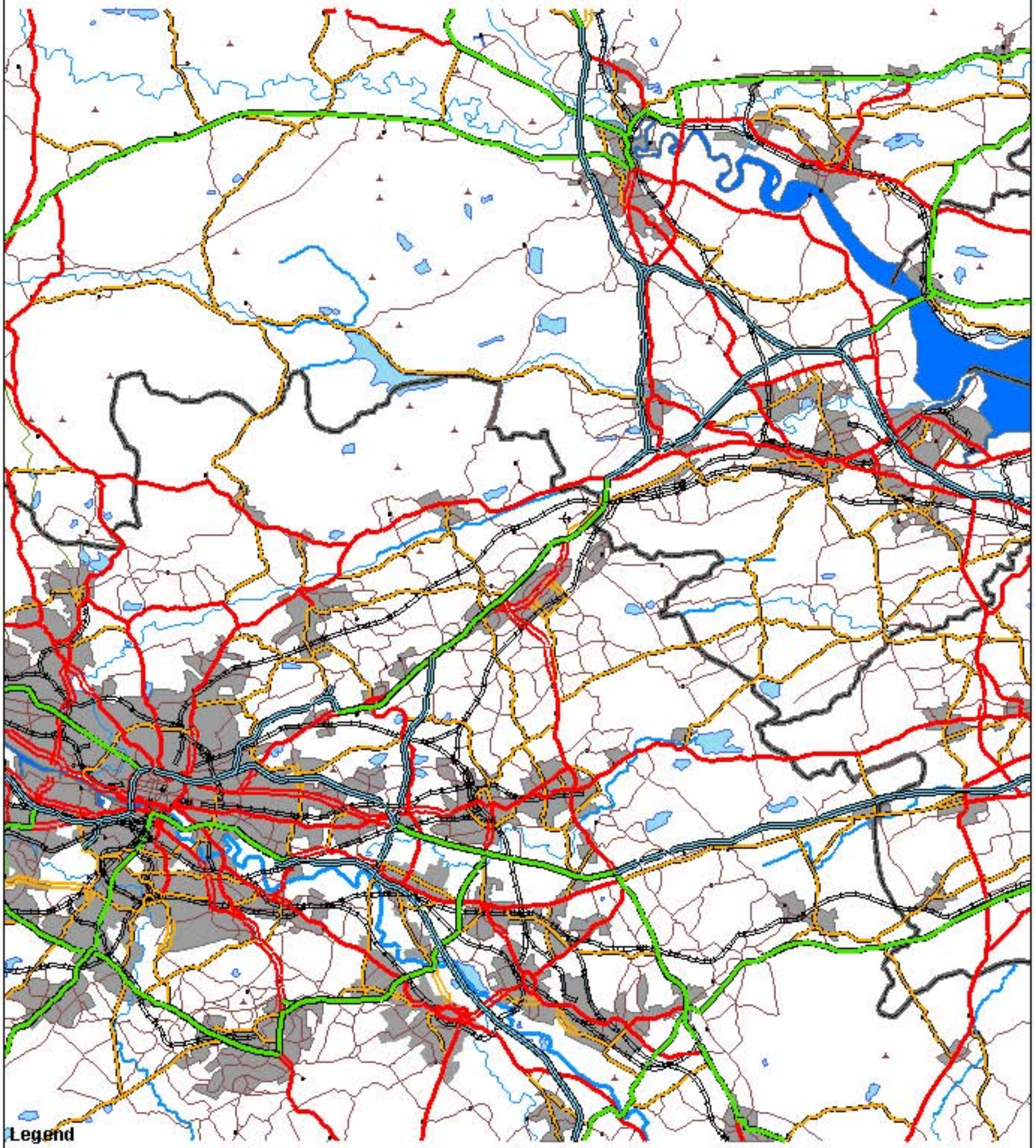


SCALE 1:500 000

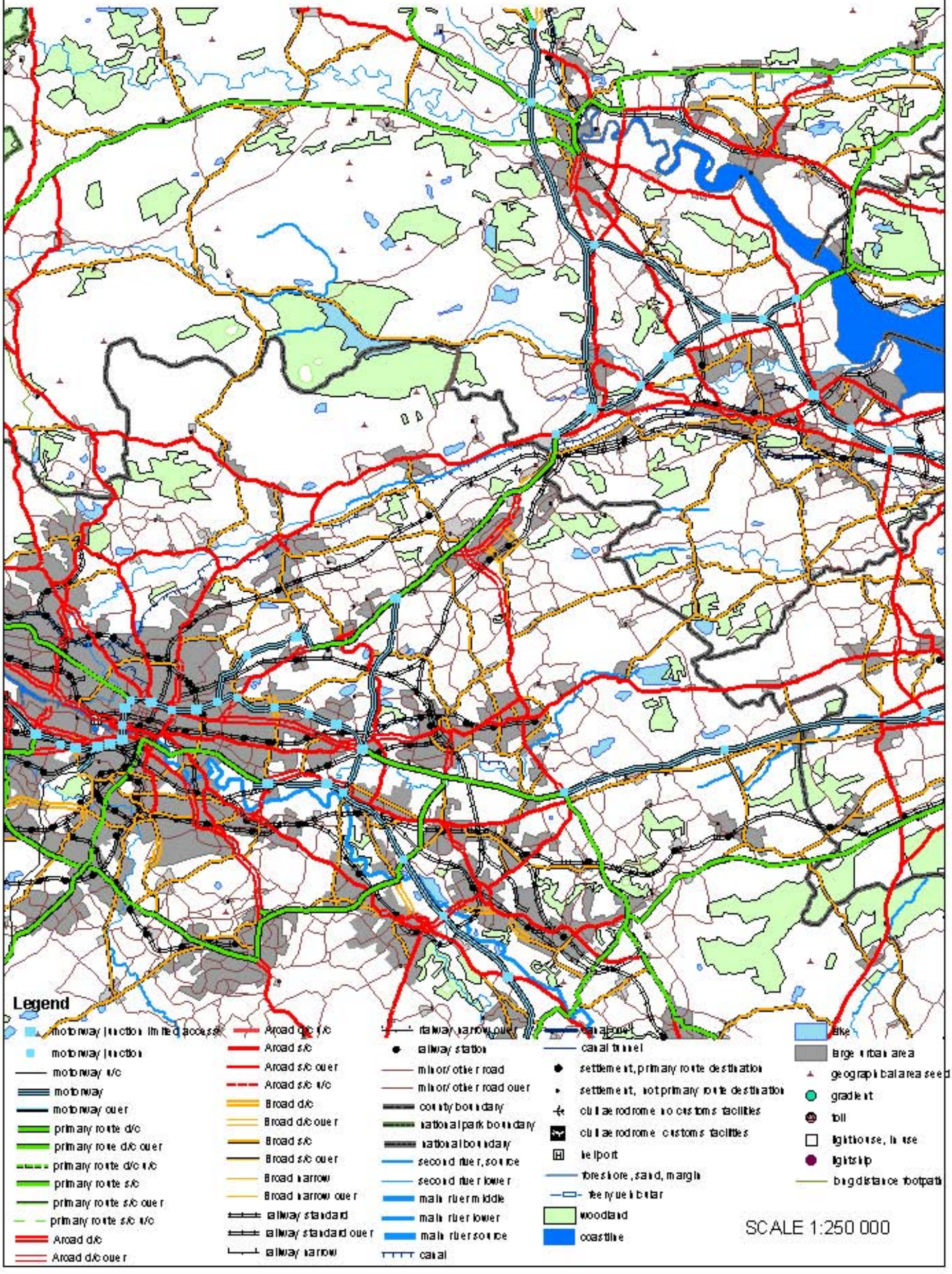
Legend

- national boundary
- second river, source
- second river lower
- main river middle
- main river lower
- main river source
- settlement, primary route destination
- settlement, not primary route destination
- coastline
- lake
- small urban area
- large urban area

topographic maps LD:1



topographic maps LD:10



topographic maps LD:5